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The way it was. A captive Red-bellied black snake consuming a large *Litoria castanea*.
March 1965. (Photo courtesy of Ian Macartney).

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PAST DISTRIBUTION OF *LITORIA AUREA* AND *LITORIA CASTANEA* IN THE BATHURST-ORANGE AREA OF NEW SOUTH WALES

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ABSTRACT

While conducting surveys for the Green and Golden Bell Frog *Litoria aurea* in the Bathurst - Orange area of the New South Wales' central highlands, evidence was discovered that indicated the presence of up to three species of Bell frogs in this region from the late 1940's to the 1970's. The identity of two species, *L. aurea* and *L. castanea* was confirmed by photographic evidence. The presence of *L. raniformis* could not be independently confirmed despite the amount of supportive information provided by local herpetologists. Records kept by various amateur naturalists indicated that *L. aurea* persisted in the Bathurst area until 1973 but was not recorded from Orange; *L. castanea* was present at Bathurst until 1969 but persisted in the Orange area until at least 1977. Information obtained from local herpetologists indicated that *L. castanea* and *L. aurea* used different types of waterbodies and only co-existed at one site to the south of Bathurst (Wimbledon). The disappearance of the Bell frogs coincided with major habitat changes and the appearance of Plague Minnows *Gambusia holbrooki* in the local river systems.

A comparison of the external features of the *L. castanea* from Bathurst and Orange indicated that these frogs were most similar to the southern tablelands form of *L. castanea*. Examination of museum specimens indicates that this form may have also been present in areas to the west of the southern highlands, such as Narranderra and Holbrook. This evidence suggests that *L. castanea* may have had a continuous distribution along the west-

ern slopes of the Great Divide from the Snowy Mountains to the New England Range. *L. castanea* disappeared from the Bathurst-Orange area (1977) after it disappeared from the New England Area (1975) and before it disappeared from the southern tablelands (1979).

INTRODUCTION

The Green and Golden Bell Frog *Litoria aurea* and several other frog species form a recognised group of closely-related species known as Bell frogs (Courtice and Grigg 1975). Other members of the species group include *L. raniformis* and *L. castanea/flavipunctata* (see Thomson *et al.* 1996) in southeast Australia, *L. dahli* in northern Australia and *L. moorei* and *L. cyclorhynchus* in southwestern Australia.

At the time of European settlement of Australia, there were at least three Bell frog species in New South Wales (NSW) and the Australian Capital Territory (ACT). These include *L. aurea*, *L. raniformis* and *L. castanea / flavipunctata* (Osborne *et al.* 1996). The last of these species is known from specimens from two disjunct populations, the northern one being previously known as *L. flavipunctata* (Courtice and Grigg 1975) and the southern one as *L. castanea* (Cogger *et al.* 1983). We follow Thomson *et al.* (1996) in treating these populations as part of a single species, *L. castanea*.

In NSW all Bell frog species have declined dramatically, especially west of the Great Divide (White and Pyke 1996, Osborne *et al.*

1996). *L. raniformis* is apparently the only extant Bell frog species remaining in the region. *L. aurea* once occurred throughout the Southern Tablelands but has not been reported from this area since 1968 (this paper). *L. castanea* is apparently extinct, having been last recorded on the New England Tableland and Southern Tablelands in the late 1970's (Osborne *et al.* 1996). Populations of *L. raniformis* have also disappeared from the Southern Tablelands (Ehmann and White 1997).

Due to the lack of published records, the pre-European distributions of Bell frogs west of the Divide in NSW are not clear. There is general agreement that *L. castanea* was confined to the two isolated populations previously described. (Osborne *et al.* 1996). However, examination of Bell frogs in Australian museum collections indicate that the area between the Southern Tablelands and New England Tablelands was not intensively sampled.

The lack of representative information about Bell frogs from the central west of NSW also means that ecological information about these frogs in sympatric areas is missing. For example, it is not known if Bell frogs co-occurred in the same water bodies, or the patterns of habitat use for each species.

The reasons for the declines of Bell frogs in the central west are also unclear. The Plague Minnow *Gambusia holbrooki* has been implicated in the decline of *L. aurea* (Morgan and Buttemer 1996, White and Pyke unpublished) but Bell frogs have disappeared from a number of locations in the southern and northern tablelands where *Gambusia* is reportedly absent (Osborne *et al.* 1996). Unusually long periods of drought have been suggested as the cause of the decline of Bell frogs in the Southern Tablelands (Osborne *et al.* 1996). This may be a factor although long droughts have occurred many times throughout Australia's history and Bell frogs have survived to recolonise areas in better times.

The aim of the present study was therefore to:

1. Improve our knowledge of the early distribution of Bell frogs west of the Great Divide in NSW
2. Compare patterns of habitat use by the different Bell frogs, particularly in sympatric areas
3. Examine the relationship between the declines of Bell frogs and changes in habitat.

METHODS

In order to differentiate between the different Bell frog species we have adopted the approach of Thomson *et al.* 1996. This method employs 17 external characteristics to distinguish between southeastern Bell frog species but is also capable of discriminating between the northern and southern forms of *L. castanea*.

Because Bell frogs are apparently extinct throughout much of the central west of NSW, we have had to rely on various kinds of historical information, together with recent visits to past sites where Bell frogs had been recorded. A considerable amount of time was devoted to interviewing herpetologists from the Bathurst-Orange area. Many of these amateur naturalists had compiled extensive field notes and information about the fauna of the local area over various time periods. Where possible records were cross-checked by seeking confirmation from other herpetologists who were active at that time or who also had records from the same or similar locations. Copies of photographs and sketch maps were also collected along with photocopied pages from field note books.

Apart from collating information about Bell frogs, we were also able to glean information about habitat changes over time, particularly from 1945 onwards. These include flood histories for the Macquarie River, changes in patterns of land use in the river valley and the first appearance of exotic fish. Again, where possible, this information has been cross-checked using the resources of the Bathurst City Council.

Finally, museum specimens were examined and re-evaluated in light of the information found during this study. Museum specimens were scored according to the criteria presented in Thomson *et al.* 1996.

Specimens Examined

Litoria castanea:

Australian Museum: R 8421, R 32183-91, R32545-54, AM R 69026-29.

University of Canberra: CA536, UC 0047, UC 0155

Aust. National Wildlife Collection: A0218, A0649, A1280, A1495

Litoria raniformis:

Australian Museum: R 5233, R3121-23, R9480, R74891, R78798, R87659, R74603-05, R90619, R93881, R111001-2.

National Museum of Victoria: D 10712, D19051-54, D19062-2, D19176, D19472-74, D19593-7, D19603, D19608-9, D 19661, D19729-30, D19732, D62329-33.

Litoria aurea:

University of Canberra: CA 150, CA 155, CA 314-329.

National Museum of Victoria: D 19617.

RESULTS

Comparisons of *Litoria castanea* from the New England and Southern Tablelands

Bell frogs from the Australian Museum and the University of Canberra's herpetological collection were examined. Frogs determined to be *L. castanea* (as listed above) were compared and external differences noted. Thomson *et al.* (1996) presented 17 external features to distinguish the Bell frogs of south-east Australia, but only two of these features (character 8: markings on undersurface of thighs and groin, and character 14: presence of yellow spots on feet) could be used to separate the New England and Southern Tablelands form of *L. castanea*.

L. castanea from the Bathurst-Orange Area

Photographs supplied by Mr Ian MacCartney (I.M.) of *L. castanea* from Bathurst and photographs supplied by Mr Doug Binns (D.B.) of

L. castanea from the Orange area were the strongest evidence for the existence of this species in the central west of NSW. Some of the photographs depicted diagnostic features that enabled a comparison of the markings and skin patterns of these animals with northern and southern forms of *L. castanea*. Using characters 8 and 14 from Thomson *et al.* (1996), the Bathurst and Orange frogs were most similar to the Southern Tablelands form of *L. castanea*. Superficially, the most distinctive feature of this group is the pattern of small white spots, edged in black on the back of the thighs. In the northern form of *L. castanea* yellow splotching occurs along the thighs (see Courtice and Grigg 1975).

Types of Bell Frogs from the Bathurst Area

At least two species of Bell frog occurred in the Bathurst-Orange district from the late 1940's to the late 1970's (Figure 1). Herpetologists who were active during this period attested to the existence of smooth (*L. aurea*) and warty (*L. castanea* or *L. raniformis*) Bell frogs being present in a number of locations in the district. It was generally assumed by local herpetologists that the warty form was *L. raniformis* and it was a complete surprise to many when it was suggested that the warty form may have been *L. castanea*. Most of the information that was supplied and which could be verified concerned *L. aurea* and *L. castanea*. No photographic evidence or specimens were forthcoming to confirm the existence of *L. raniformis* in this region.

Distribution of the Green and Golden Bell Frog (*Litoria aurea*)

Records of the Green and Golden Bell Frog were available for several areas in the Bathurst district but not for the Orange area. These demonstrated that *L. aurea* was continuously present around Bathurst between 1952 and 1969. The records were provided by a number of amateur naturalists and snake keepers who collected Green and Golden Bell Frogs to feed captive snakes. Green and Golden Bell Frogs were collected as they were a common species, a large food

item and were often present in high densities in the local area.

Green and Golden Bell Frogs were present in a number of ponds and drains along the Macquarie River but the main collecting areas were to the south of Bathurst, at White Rock, Charlotte's Creek and Wimbledon, and to the north of Bathurst at Eglington (Figure 1). These areas were chosen because frog numbers were high and access was easy. Green and Golden Bell Frogs were regularly collected at Bathurst from the early 1950's through to the mid-1960's. In the latter part of this period they were collected from ponds on the floodplain immediately south of Bathurst and from within Bathurst township, in timber wells near Stevens Lane and from abandoned clay pits near Hereford Street and Raglan Street. These structures no longer exist. Thirty kilometres to the east of Bathurst, Green and Golden Bell Frogs were regarded as "common" at Winburndale Dam (I.M.) The consensus amongst the herpetologists interviewed was that Green and Golden Bell frogs declined rapidly in the late 1960's and were rarely collected after 1967. The last positive record appears to be from Charlton in 1973.

One herpetologist (I.M.) was able to provide information about the Bell frogs in the late 1940's and early 1950's. His records indicated that Green and Golden Bell Frogs were not particularly common around Bathurst after WWII. Their abundance increased during the next few years to a point where they became the most commonly collected frog in 1950. *L. aurea* remained as the most-readily collected frog for this herpetologist until 1966 when there was a noticeable decline in numbers. The frogs were collected only occasionally after this time and collecting ceased in 1969 when they became so uncommon that other food sources were sought as snake fodder.

During the period from 1948 to 1965 the Macquarie River underwent a number of significant changes. Unlike today, the river was wide with large sandy banks. There were large sand islands, some of which were later

mined. The banks of the river were lined with willows and the southern floodplain was used as grazing land. Over the years an increasing numbers of drainage ditches and channels were constructed to take water from the low-lying parts of the floodplain to the river. Some of the low-lying sites were excavated to act as water sources for grazing stock. Bulrushes (*Typha* sp.) were not common along the river or on the floodplain.

During the late 1950's and early 1960's the Macquarie River became heavily nutrified as the result of inadequate treatment of sewage. Discharge from large market gardens established on the floodplains also contributed to the effluent. Large algal mats formed in the river and during dry periods, the river became foul-smelling. For several years, swimming in the river was prohibited. During this period, bulrushes emerged as the most common, large aquatic plant and lined large sections of the river, channels and ponds. The water quality of the river has subsequently improved with changes in market gardening practices and the treatment of the town's sewage effluent. Plague Minnows (*Gambusia holbrooki*) were not present in the river in appreciable numbers until 1965 (they were first noted at Raglan in 1964). These fish reached high densities within the first two years of their appearance in the Macquarie River and this situation still remains. Over successive years *Gambusia* became established in more isolated farm dams, reservoirs and channels.

Yellow-spotted Bell Frog (*Litoria castanea*)

The presence of *Litoria castanea* in the Bathurst-Orange area was confirmed by photographic evidence (see Figure 2 and cover photograph). The existence of this species in the area had not been suspected by regional herpetologists. In general, they did not discriminate between *L. raniformis* and *L. castanea*; both were regarded as varieties of "warty" Bell frogs. However, the white spotting on the back of the thighs of some of the warty Bell frogs was noted (I.M. pers. comm.)

but dismissed as intra-specific variation. *L. castanea* was not as widely distributed as *L. aurea* and was collected irregularly for snake food from only two sites; from the large ponds which acted as the water-refilling points for the steam trains at Wimbledon (see Figure 1), south of Bathurst, and from a pond adjacent to the Macquarie River, 2 kilometres south of Bathurst. The last record of *L. castanea* from the Bathurst district was made in 1969 from Wimbledon (I.M.).

The only record of *L. castanea* from the Orange district was in the form of a photograph taken on a farm, approximately 4 kilometres south of Millthorpe (Doug Binns, pers. comm). The frogs were calling during the day from a drain that ran through a boggy section of pasture. The pasture had been pitted by cattle hoof prints paths leading to drinking points. The paddock was cleared of trees and comprised a mixture of native and exotic grasses. The frogs continued to call throughout the night and it was estimated that ten frogs were seen in the pasture. This record was made in October 1977.

Southern Bell Frog (*Litoria raniformis*)

The Southern Bell Frog *Litoria raniformis* appears to have been a much less common frog in the Bathurst area and is not well documented. This species did not appear to undergo a population increase during the 1950's and 1960's and remained as a rarely collected frog in the local area. The main areas where *L. raniformis* was collected were from Eglington and from the banks of the Macquarie River immediately south of Bathurst. The last account of *Litoria raniformis* from the district was from the low level bridge at George Street in Bathurst in 1970 (Gavin Waters; G.W.).

***L. castanea* from South-west slopes**

From an examination of museum specimens it appears that the southern highlands form of *L. castanea* may have also occurred in areas to the west of the southern highlands. Specimens from near Narrandera (AM R 69026-9), Mount Horeb (AM R 8421), Delegate (NMV D 19062-3, D19593-7, D 19603,

D 19729-30, D 19732) and Holbrook (NMV D 19176, D 19608-9) appear to have markings consistent with the southern tablelands form of *L. castanea*.

DISCUSSION

Past Distribution of *L. castanea*

The evidence from this study suggests that the southern tablelands form of *L. castanea* had a much greater distributional range that previously believed (White and Ehmann 1997a and b). The species appears not to have been solely confined to the southern tablelands but to have occurred as far north as Bathurst and as far west as Narrandera. These are quite substantial increases in distributional range and suggest that further efforts are required to collect additional distributional information for the area between Bathurst and the New England tablelands. Should populations be found in this region, it may be concluded that *L. castanea* had a continuous distribution between the New England area and the southern tablelands (as suggested by the distribution map in Cogger 1994). This, in turn suggests, that the New England and southern tablelands populations that existed in the 1960's and 1970's may have been the last remnants of a species that was progressively diminished from the central parts of its range. These remaining highland sites may not have been ideal habitats for these frogs, but merely their last refuges prior to extinction.

Reasons for the decline of Bell Frogs in the Bathurst Area

Two factors appear to be implicated in the decline and disappearance of Bell frogs from the Bathurst area: habitat loss and increased predation by Plague Minnows *Gambusia holbrooki*. In the late 1940's and early 1950's there were many artificial water bodies around Bathurst. Wells were common in and around the town as well as on the floodplain. In addition, abandoned quarry and mine sites were present close to town, and many of these collected water to form near-permanent ponds. These isolated ponds and pools were the only areas where local herpetologists

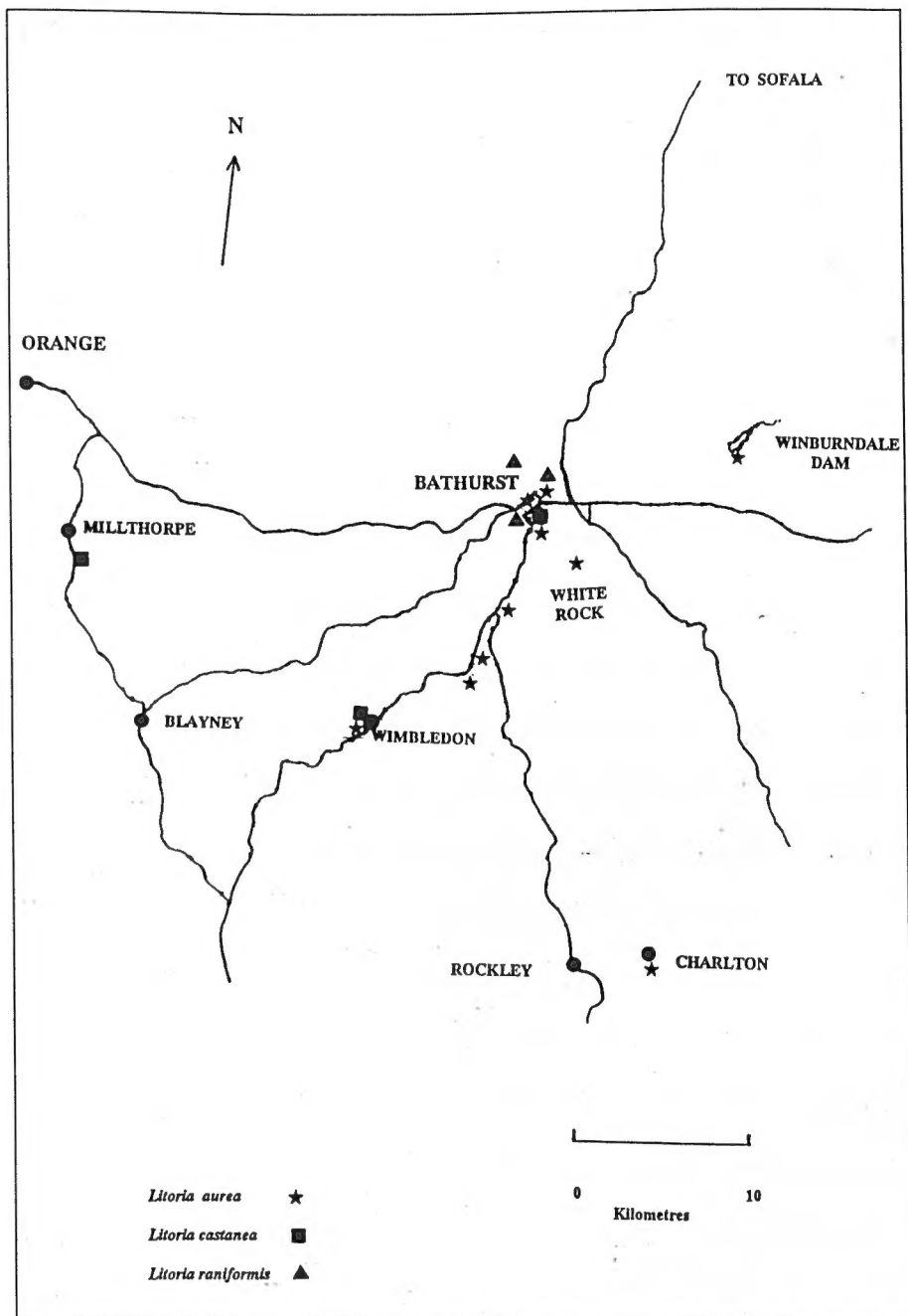


Figure 1 Map showing the confirmed sites for *Litoria aurea*, *L. castanea* and *L. raniformis* in the Bathurst-Orange district.

observed spawning or saw tadpoles that were probably those of Bell frogs. Calling was heard in various locations along the Macquarie River but there was no evidence that spawning actually occurred in river sites.

During the 1960's the condition of the Macquarie River had seriously deteriorated due to sewage and agricultural effluent discharge into the river. Concurrent with these changes was the loss of many of the wells as town water supplies became better established. More extensive series of drainage channels and ditches were created across the floodplain which ensured that flood waters no longer accumulated near Bathurst. These activities removed most of the previously known Bell frog breeding sites.

In 1965, *Gambusia* was first recorded in the Macquarie River at Bathurst. The fish were already in large numbers and were present along most of the river. Within a few years, the fish also appeared in the old clay pits near Bathurst and within 10 years there were few waterbodies that did not contain *Gambusia*. By 1971, Bell frogs had disappeared from Bathurst and by 1973 the last Bell frogs were recorded at Charlton (G.W.)

The disappearance of Bell frogs from the southern tablelands appears to be unrelated to the presence of *Gambusia* as the frogs disappeared from areas that were fish-free (Osborne *et al.* 1996). Instead, the decline may be related to abnormal weather patterns from 1977 to 1982 when virtually no rain fell in the October to December breeding period. This highly abnormal weather pattern, combined with changes in land use appears to be the main cause for the decline in these areas.

Northern Range of *Litoria raniformis*

Assertions that *Litoria raniformis* were also in the Bathurst area could not be positively confirmed. No specimens had been collected and no photographs were produced of this frog. Despite this we are reluctant to dismiss these claims too quickly as they had been made independently by different naturalists.

Based on museum specimens, the northernmost record of *L. raniformis* is from Tarana (AM R 3121-23), only 40 kilometres from Bathurst. These specimens were collected in 1900. Since that time, *L. raniformis* has been collected from Trunkey (AM R 93881), about 60 kilometres south of Bathurst in 1978. In surveys of *L. raniformis* sites in New South Wales conducted between 1993 to 1995 (Ehmann and White 1997) *L. raniformis* were not found north of the Murrumbidgee River.

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Figure 2 Photograph of a captive Tiger Snake consuming an adult *Litoria castanea*. Note the patterning on the thighs. (photograph courtesy of Ian Macartney). 1966.

A NOVEL METHOD OF IDENTIFYING SEX IN NEONATE LITTLE WHIP SNAKES *SUTA FLAGELLUM* (ELAPIDAE)

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The identification of sex in immature snakes can sometimes be difficult owing to the lack of obvious or reliable external characteristics that differentiate the sexes. Secondary sexual characteristics generally develop with maturity in a species, if they are at all present. In the absence of such characteristics, invasive techniques such as probing are often employed. The technique of probing is used to determine sex by measuring the relative depth to which a probe can be inserted down tail invaginations (for a discussion of the technique see Ross & Marzec (1990), pp.41-60). In females these invaginations correspond to the cloacal (scent/musk) glands, while in males they correspond to the (inverted) hemipenes. The paired cloacal glands lie at the base of the tail in both female and male snakes, being dorsal to the hemipenes in males (Whiting 1969 in Kissner *et al.* 1998). The cloacal glands of females have been reported to be larger in females and in males and this has been quantitatively shown for a few species (Kissner *et al.* 1998 and references therein). Typically females probe to a much shallower depth than males, presumably reflecting the greater length/diameter of the hemipenes compared to the female cloacal glands. Probing is widely used in both adult and immature snakes. However probing can be unreliable in some immature snakes owing to their small size, and in the extreme, is not possible to perform without risk of injury to the snake.

The accurate identification of sex in immature snakes is important in several respects: it enables the collection of data on the primary sex ratio, it may lead to the identification of secondary sexual characteristics, and it enables the more effective management of live snake collections. In this note I describe a

non-invasive method that permits the accurate identification of sex in neonates of one particular elapid species, and which may prove useful in other snake species.

The Little Whip snake, *Suta flagellum*, is a small live-bearing elapid found in Victoria and the south-eastern portions of NSW and SA (Cogger 1992). Adult *S. flagellum* have particularly striking secondary sexual characteristics in the form of tail length and shape; these permit the unambiguous identification of sex (Rawlinson 1965, Fyfe and Booth 1984, Turner 1989, 1992). Adult males possess longer tails that increase in thickness past the vent before tapering, whereas females have shorter uniformly tapering tails (see Turner (1992) for diagram of adult male-female tails). In neonates this difference in shape is not nearly so apparent with most having uniformly tapering tails (resembling those of adult females; Turner 1989). The difference in tail shape usually becomes apparent after several months growth and well before adult size is attained (*pers. obs.*). There is, as in adults, a significant difference in tail length between male and female neonates (Turner 1989, *in prep.*) and this trend was determined using the method described below to establish sex. Within single litters, when both sexes are present there is usually no difficulty in differentiating males and females using tail length. Occasionally, however, individuals were encountered that had tails of 'intermediate' length and thus the tail length criterion alone was inadequate. It can also be difficult to apply if there are no other individuals available for comparison. Probing neonate *S. flagellum* was not attempted, but even if it is possible to perform without injury to snakes, it is doubtful whether the technique

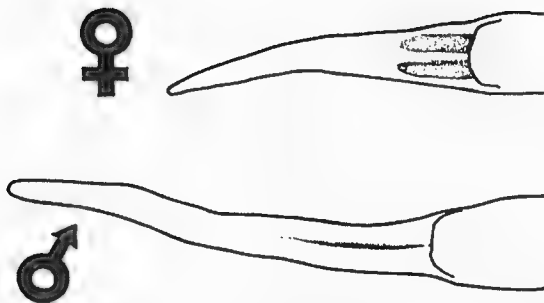


Figure 1

Drawing depicting the observed anatomical differences between neonate female and male *Suta flagellum* as viewed through wetted subcaudal scales. The female (upper) has two clearly visible cloacal glands, while the male (lower) has no visible cloacal glands or hemipenes.

would permit complete resolution of the sexes due to their small size (mean SVL=115mm, n=70).

A reliable alternative method of determining sex in neonate *S. flagellum* was found. This method provided the basis for determining the sex of neonates. The method relies on the semi-transparency of the subcaudal scales that allow internal structures to be viewed. Sex is therefore determined directly from internal anatomical features. Viewing is however often made difficult by the fact that a significant area of the subcaudal surface consists of overlapping scales. Attempting to resolve structures through two layers of scales is more difficult than through one, however by wetting the surface its transparency is significantly improved to the extent that some internal structures can be resolved. Evidently water is sucked in between overlapping scales by capillary action and the presence of water (rather than air) in this region significantly improves viewing because it reduces the amount of light being internally reflected. Normally the subcaudal region was wetted using a mist spray and the water droplets were then smeared over the surface. There were clear differences in the internal structure of males and females as viewed through the wetted subcaudal scales (see Figure 1). In neonate female *S. flagellum* a pair of pale brownish

cloacal glands extend posteriorly from the cloaca and clearly terminated after about 5mm (range 3.0-4.5mm; n=34; as measured from the proximal edge of the vent scale). In males no corresponding structures were evident. Instead the hemipenes were indistinct and therefore of indeterminate length. All that could be discerned was a thin dark region along the mid-line. This is probably a consequence of the cloacal glands lying dorsal to the hemipenes and being of smaller size. These observed differences were confirmed by the dissection of a small number of stillborn neonates (n=4; two of each sex). This method permitted the complete resolution of sex in all neonates examined (n=70). The method is however limited to neonates because the ability to resolve structures through the subcaudal scales progressively decreases with age in *S. flagellum* (pers. obs.). This is because the subcaudal (and ventral) scales become increasingly opaque as pigment is deposited in them. The method has also proved accurate to the extent that a small number of neonates (n=11) retained in captivity, subsequently developed tail shapes consistent with their sex as determined by the method.

It would be interesting to determine whether this method can be successfully applied to other snake species. Martof (1954) for exam-

ple observed that cloacal glands were visible through the (dry) subcaudal scales in neonate female Gartersnakes, *Thamnophis s. sirtalis* but no corresponding structures were evident in males. Neonates of many snake species have a semi-transparent ventral surface (pers. obs.) so this requirement of the method is likely to be satisfied by many species, however whether cloacal glands or hemipenes can be adequately distinguished remains to be determined. I am not aware of the method being used to determine the sex of neonates of Australian snake species.

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DIET AND CAUSES OF MORTALITY OF THE TRILLING FROG (*NEOBATRACHUS CENTRALIS*).

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ABSTRACT

Neobatrachus centralis is a common burrowing frog in the arid regions of South Australia. The diet of *N. centralis* is largely determined by the availability of arthropods while frogs are active, with little apparent selectivity. Desiccation was the primary cause of mortality, particularly prior to metamorphosis. Tadpoles were rarely attacked by predators, which suggests some form of protection by toxins. Although metamorphlings and adults were taken by a variety of predators, they were seldom exposed to predation.

INTRODUCTION

Frogs can be extremely abundant in the Australian arid zone (Read 1992, 1998, Morton *et al.* 1993, Predavec and Dickman 1993) and hence may play an important part in ecosystem functioning. However, detailed ecological studies of Australian arid zone frogs are lacking (Morton *et al.* 1993, Predavec and Dickman 1993), which is largely attributable to the difficulty of access to many arid sites during rare and unpredictable wet periods (Tyler 1990). Increased investigation into the biology and conservation status of poorly known genera inhabiting arid areas is therefore warranted (Tyler 1997).

The Trilling Frog (*Neobatrachus centralis*) is a widespread burrowing frog which inhabits central Australia (Barker *et al.* 1995). *Neobatrachus centralis* is possibly the most abundant vertebrate in some regions (Read 1992) and has been used as a bioindicator of contaminant levels in the environment (Read and Tyler 1990, 1994, Read 1997). However, the ecology of this important species is largely undocumented. The diet and causes of mortality of *N. centralis* were investigated in this study.

METHODS

Study region

Neobatrachus centralis were studied at Olympic Dam (30°29'S, 136°53'E), approximately 520km north of Adelaide in South Australia. Rainfall at Olympic Dam is aseasonal and unpredictable and fails to reach the long-term average of 166mm in about 60% of years (Read 1995). Major summer rainfall events, which typically yield 70-200 mm every 2-5 years, are essential for mass breeding of *N. centralis* (Read unpubl. data). The predominant vegetation associations of the study region are chenopod shrublands on clay swales interrupted by *Acacia* shrublands on linear orange sand dunes.

Sampling

Dietary information was collected through stomach analysis of individuals killed on roads and direct observations of foraging frogs. Tadpoles in natural ponds were observed until metamorphosis during the major breeding events of 1989, 1992 and 1997, and predation events or cause of death were noted. Predation was assessed through observations and stomach analysis of large reptiles which were killed on roads, or cats and foxes which were shot.

RESULTS

Diet

Diets of *N. centralis* were assessed from 67 road-killed specimens and 5 opportunistic observations. *Neobatrachus centralis* consumed a wide variety of arthropods (Table 1). Ants were the most abundant dietary item recorded in 48% of samples and were also recorded in a further 34% of the stomachs. At least 13 ant taxa were eaten in frequencies

generally representative of the local ant population densities. However, none of the abundant *Melophorus* genus, and relatively few of the common *Iridomyrmex rufoniger*, were eaten. By contrast, the abundance of *Pheidole* were over-represented in their diets compared with abundances trapped in the region by pitfalling (Read 1996).

Termites were important prey, being the most abundant prey in 20% of samples, but not to the extent reported for other desert frogs (Calaby 1956, Dimmitt and Ruibal 1980, Predavec and Dickman 1993). Spiders and beetles were also important prey items (Table 1), particularly given their larger size compared with ants and termites. One incident of cannibalism of a metamorphling by an adult was recorded. All four specimens collected immediately after the commencement of rain had eaten the cocoon formed by their shed skin, this possibly took place underground.

Unlike the Water-holding Frog (*Cyclorana platycephala*) which often feeds in the water (Robinson and Cappel 1989), no evidence of aquatic foraging was recorded in *N. centralis* at Olympic Dam.

Mortality

Desiccation was by far the most significant cause of mortality for *N. centralis*, particularly for tadpoles and metamorphlings. During each major breeding event, many thousands of tadpoles died when their ponds dried prior to metamorphosis.

Tadpoles which died in desiccated ponds were seldom consumed and predation on live tadpoles was only confirmed for *Iridomyrmex* ants encroaching drying ponds. Although waterbirds, such as herons and gulls were occasionally observed feeding in ponds containing tadpoles, they may have been feeding on invertebrates which were also common in ponds. Direct observations and perusal of scats and tracks in fresh mud indicated that dense populations of tadpoles which remained in deep ponds for several months were not targeted by either waterbirds or scavengers such as corvids or kites which

were locally abundant. However, metamorphlings apparently suffer considerable predation pressure from water beetles, *Megacephala* and other carabids, and from large *Iridomyrmex* ants (pers. obs.). Nearly 8% of metamorphling *N. centralis* collected exhibited serious injuries which were observed or attributed to beetle attack (Read unpubl. data). Since injuries were rare in adult frogs, many of these injuries were probably fatal.

Metamorphlings were also preyed upon by adult frogs, Mulga Snakes (*Pseudochis australis*) and foxes. Foxes, cats and Mulga Snakes were also recorded feeding upon adult frogs at night after rain on several occasions. A pet Tawny Frogmouth (*Podargis strigoides*) regularly took dead *N. centralis* adults which were offered.

DISCUSSION

Neobatrachus centralis is best considered to be an opportunistic insectivore (Predavec and Dickman 1993), with little apparent selectivity in prey items. The importance of ants in their diet reflects the local numerical dominance of ants in pitfall traps, which are typically nearly twice as abundant as all other invertebrates combined (Read 1999). Biases in ant taxa consumed compared to their abundance at Olympic Dam was probably not a reflection of prey selection by *N. centralis*, rather a function of the variability in activities of ant taxa in wet weather compared to dry hot days when ant monitoring was conducted. *Melophorus* and to a lesser extent *Iridomyrmex* are most active on hot days (Briese and Macauley 1980, Read 1996) and probably were not represented in the frog's diet because they were not active on wet nights. On the contrary, *Pheidole* are more active in cool wet weather (pers obs) and produce alate sexuals which mate in swarms (Briese and Macauley 1977), which probably explains the relatively high numbers encountered by frogs.

The importance of termites may be underrepresented in this sample because termite activity is highest during the first night of rain

whereas many of the road-killed frogs were collected several days after rain. Predavec and Dickman (1993) argued that the high proportion of termites in the diet of both *Notaden nichollsi* and *Neobatrachus centralis* relative to the number of termites trapped or observed on the surface may be explained by the frogs burrowing into termite galleries, yet no proof of this has been observed.

Most adult arid-adapted frogs, such as *N. centralis*, probably only feed during brief periods following heavy rainfall events. Dimmitt and Ruibal (1980) estimate that the Couch's Spadefoot Toad (*Scaphiopus couchii*) from North American deserts only needs to ingest two or three meals to provide their annual energetic requirements. An even more impressive fact is that the largest 15% of *Cyclorana platycephala* are capable of surviving for over five years without feeding (van Beurden 1982). Since invertebrates are typically also abundant following heavy rain in the arid zone, the brief feeding periods of frogs coincides with maximum prey availability. This not only minimises frog's exposure to predation but probably also minimises their competition for food resources with reptiles, which are also abundant terrestrial insectivores in the Australian arid zone.

Tadpole desiccation is probably the most important cause of mortality in *N. centralis*. Therefore, arguably the most important trait allowing *N. centralis* to inhabit extremely arid localities is their ability to metamorphose rapidly. As with other desert frogs, the timing of metamorphosis may be influenced by the degree of crowding and food supplies (Semlitsch and Caldwell 1982) but can apparently be accelerated in shallow ponds to maximise chance of recruitment (Wilbur 1987, Newman 1989). A hormone that induces premature births in humans, is probably also the agent for accelerated metamorphosis of tadpoles in drying ponds (Denver 1997).

Neobatrachus tadpoles may be unpalatable to predators or indeed may be protected by

toxins, which were the probable cause of death of a frog-specialist Common Tree Snake (*Dendrelaphis punctulata*) which died within a day of being fed the tadpoles of *Neobatrachus pictus* (J. Keynes pers. comm.). Many species of tadpoles are either unpalatable or produce skin secretions with unpleasant physiological effects on predators (Wasserug 1971, Low 1976, Kruse and Stone 1984, Kats et al. 1998). Low larval predation rates would benefit *N. centralis* by allowing slow metamorphosis unless pond desiccation is imminent. Slower metamorphosis may produce larger metamorphlings which are probably less susceptible to desiccation (Newman 1989).

However, predation rates apparently increase following metamorphosis, perhaps due to an increase in palatability or decrease in toxicity. Recently metamorphosed individuals may also be in a weakened condition and predation can be important at this stage (Mayhew 1965, Wassersug and Sperry 1977, Werner 1986). These factors may explain why water and terrestrial beetles prey extensively on recently metamorphosed individuals, whereas predation upon large tadpoles is apparently rare. Predation on adult *N. centralis* by a range of mammal, bird and reptile suggests that their toxicity at this stage is minimal. However, no incidences of frog predation were recorded when the frogs were not active, suggesting that predators did not excavate frogs from their subterranean retreats. Therefore, frogs were apparently only exposed to predation during the short periods when they were active after rain.

Like *S. couchii* (Tinsley and Tocque 1995), *N. centralis* apparently experiences high tadpole mortality but good survival following maturity (Read unpubl. data). Longevity is important for frog populations in severe habitats (Teviss 1966), particularly when breeding opportunities may only eventuate once every decade or so (Morton et al. 1993).

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Table 1. Dietary information from 72 *N. centralis* from Olympic Dam

Prey type	number of frogs	% of frogs containing prey	Total number of prey items
Coleoptera	13	18	22
Blatodea	1	1	1
Hemiptera	5	7	14
Orthoptera	2	3	3
Diptera	2	3	2
Isoptera (winged)	11	15	61
Isoptera (not winged)	18	25	153
Hymenoptera:			
wasp	3	4	4
ant	59	82	451
<i>Camponotus</i>	10	14	13
<i>Brachyponera lutea</i>	3	4	3
<i>Iridomyrmex rufoniger</i> (sp. b)	12	17	47
<i>Iridomyrmex rufoniger</i> (sp. e)	7	10	14
<i>Iridomyrmex viridiaeneus</i>	10	14	13
<i>Iridomyrmex</i> sp. f	7	10	14
<i>Meranoplus</i>	9	13	23
<i>Pheidole</i>	36	50	326
<i>Polyrhachis</i>	1	1	1
<i>Rhytidoponera metallica</i>	30	42	65
<i>Rhytidoponera</i> sp. a	1	1	1
<i>Tetramorium</i>	12	17	31
Insect larvae	10	14	15
spider	24	33	48
red mite	2	3	2
centipede	1	1	1
juvenile frog	1	1	1
frog skin	4	6	4
seed	3	4	8
saltbush leaf	1	1	1

OOPHAGY IN THE LOWLAND COPPERHEAD *AUSTRELAPS SUPERBUS* (ELAPIDAE) IN THE MELBOURNE METROPOLITAN AREA

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INTRODUCTION

Feeding on lizard eggs has been reported in elapid snakes including *Cacophis harriettae*, *Cacophis squamulosus*, *Cryptophis nigrescens*, *Demansia psammophis*, *Drysdalia coronoides*, *Hemiaspis signata* and *Pseudonaja textilis* (Shine, 1977; Webb and Rose, 1985; Gow, 1989; Shine, 1991; and Ehmann, 1992). Lizard eggs are the sole dietary component of the *Simoselaps semifasciatus* group, (Swan, 1983; Shine, 1991; Ehmann, 1992).

Lizard eggs have been recorded as dietary items for the Pygmy Copperhead, *Austrelaps labialis* (Shine 1991). Studies of the Lowland Copperhead, *A. superbus* done in the New England region of NSW showed that reptile eggs formed part of their diet (Shine, 1977).

Prey items documented for *A. superbus* consist primarily of frogs, lizards (mostly skinks), snakes including *A. superbus*, and sometimes mice in adults, (Shine, 1977; Webb, 1984; Gow, 1989; Shine, 1991; Ehmann, 1992; Cogger, 1992; Fearn, 1994; Watharow, 1997, in prep). Wingless grasshoppers have been found in gut contents of Tasmanian *A. superbus*, (Fearn and Munday, 1996).

In areas of metropolitan Melbourne, *A. superbus* are often removed by wildlife controllers from private or commercial residences in close proximity to suitable habitats, (Watharow, 1997; in prep). Four *A. superbus* captured for removal were subsequently found to have lizard eggs in their guts.

METHODS

Forty six snakes removed from premises and euthanised by wildlife controllers, or fatally injured by dogs, humans or cats, were dissected as part of a larger study on diets and parasitism of three elapid snakes (Watharow, 1997; in prep), during the months of October to April in 1995-97.

Specimens were measured, weighed, and sexed. Stomach contents were examined, with 70 prey items removed from 26 snakes. The prey items were identified and the gut contents preserved in 10% formalin.

RESULTS

The four snakes (3 adult and 1 sub-adult) contained from 8 to 17 intact, whitish scincid eggs. These were either *Lamproholis* or *Saproscincus mustelina*, based on egg dimensions and comparison with museum specimens.

Table 1. Data on *A. superbus* with eggs in guts

SVL	VTL	WT	SEX	PREY	AREA	DATE
790mm	150mm	176g	F	8 eggs	Croydon	December 95
630mm	130mm	160g	F	8 eggs + skink tails/head	Keysborough	November 96
540mm	120mm	110g	F	17 eggs + skinks	Narre Warren	November 96
490mm	110mm	-	-	12 eggs + 3 tails	Pakenham	November 96

DISCUSSION

Lizard eggs could possibly be secondarily ingested via gravid females eaten before oviposition. The eggs perhaps being more resistant to breakdown by the digestive processes of the snake. However, with the exception of the snake from Keysborough, the skink tails and skinks in the gut were recently ingested, completely intact and clearly identifiable, so the eggs also present were not associated with those remains. The gut contents of the snake from Keysborough included a skink head, so some of the eggs could have been secondarily ingested inside this skink. In all four snakes the number of eggs exceeded that which could be contained in a single gravid female and this, together with the lack of partly digested lizards, argues against these eggs being secondarily ingested.

Saproscincus mustelina, *Lampropholis delicata* and *Lampropholis guichenoti* lay communally and have 2 - 6 eggs in a clutch (Greer 1989, Banks 1992, Ehmann 1992; pers obs). Communal nests (15-90 eggs) of *Lampropholis delicata*, *Lampropholis guichenoti* and *Saproscincus mustelina* were regularly observed within properties during snake removal. These were under overgrown ground covering vegetation, well embedded rocks, logs, railway sleepers or even in lawn grass clumps.

Shine (1977) recorded the dietary percentage of reptile eggs for *A. superbus* as 4.6% (n = 43) and *P. textilis* as 25% (n = 32) in the New England region of NSW. The number of skink eggs (45) found in this study represented dietary items in 15.3% of snakes examined with gut contents (n = 26). This suggests that lizard eggs also form part of the diet of *A. superbus* in Melbourne areas, especially in the months of November and December.

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SOME REPTILE RANGE EXTENSIONS AT LAWN HILL NATIONAL PARK, GULF OF CARPENTARIA, QUEENSLAND.

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INTRODUCTION

Lawn Hill National Park (18° 35' S 138° 35' E) is a desert oasis. Situated in the Gulf of Carpentaria, approximately 150km north of Camooweal Qld, the pristine palm lined Lawn Hill Creek flows through massive and spectacular gorges of red sandstone sparsely covered by spinifex (*Triodia* sp.). The surrounding area is of black soil plain predominantly vegetated with Mitchell grass (*Astrebla* sp.) There are also areas of limestone, which directly south of Lawn Hill harbor the incredibly rich fossil deposits of Riversleigh. Reptile life is prolific in the area (See Table 1 for a full list of species encountered by the authors). On a visit between 14th and 18th August 1995 a number of species were recorded at Lawn Hill National Park representing significant extensions in known range of three species and, for two species, confirmation of their occurrence in the region.

NEW RECORDS

The species previously unrecorded at Lawn Hill National Park are listed below with the distinguishing features used in identification and details of the records. The authors have had field experience with all five species in the months leading up to the Lawn Hill visit. Known ranges are taken from Wilson and Knowles (1988) (terrestrial reptiles only) and Cogger (1996). Specimen records from the Queensland Museum (Ingram and Raven 1991) are also discussed where appropriate.

Gehyra borroloola

On the night of 14th August 1995 a single adult *G. borroloola* was found on a rocky ridge south of Adel's Grove on the eastern

border of Lawn Hill NP. A large, pale gecko, it was distinguished from other *Gehyra* species in possessing divided subdigital lamellae (10 under the fourth toe) and 13 preanal pores (King 1983). On the 16th and 17th August 1995 this species, was found to be fairly common and active at night on the rock stacks of Lawn Hill Gorge.

Records of *G. borroloola*, from Lawn Hill NP are not all that surprising given its occurrence in sub-humid regions of the western Gulf of Carpentaria (NT) (Cogger 1996). Lawn Hill Gorge and the surrounding area is linked to this region by a series of low rocky ranges extending in a northwesterly direction for over 600km. Within these rocky ranges *G. borroloola* has been recorded in the lower catchments of the McArthur and Limmen Bight Rivers, NT (Cogger 1996) some 350-400km distant from Lawn Hill. Indeed *G. borroloola* was first encountered by the authors within its recognised range, in open woodland near sandstone escarpment, 45km southwest of Borroloola, NT. Although King (1983), in his review of the *G. australis* species' complex, stated *G. borroloola* is "restricted to the rock outcrop country and gorges surrounding the McArthur River"; no *Gehyra* specimens were examined from the region between the McArthur River area and Lawn Hill. It is thus probable that *G. borroloola* will be found to occur more widely within the series of low rocky ranges between these two localities. The distribution of *G. borroloola* is unlikely to include areas further east beyond Lawn Hill as a reasonable sample of specimens attributable to the *G. australis* complex have been collected in the ranges surrounding Mt Isa to the east, and all have been identified as *G. robusta* (see King 1983).

Heteronotia spelea

These geckos were commonly encountered on the rocky outcrops surrounding Lawn Hill Gorge. A very similar species, *H. binoei* was also commonly encountered at night along the Lawn Hill Creek. Specimens of *H. spelea* were distinguished from *H. binoei* by the possession of small tubercles on the dorsal surface, aligned to form a series of rows parallel to the midline of the back, and broad contrasting vertical bands of cream and brown along the length of the body.

From our observations it would appear that *H. spelea* occurs allopatrically with *H. binoei* at Lawn Hill, *H. binoei* occupying the riparian habitats along the Lawn Hill Creek and *H. spelea* occupying the elevated rock outcrops. The two species were never found together, as was also noted during our stay in the Top End of the NT. Compared to populations in Kakadu National Park, NT ($n = 25$ specimens examined) *H. spelea* from Lawn Hill ($n = 15$) were typically more cream than yellow in colour, with narrower, more weakly contrasting body bands. Three individuals which were examined closely had a dark brown streak from nostril to temple.

On the night of 16th August 1995 on the Island Stack, abundances of *H. spelea* appeared to be greatest on the sheltered slopes of the outcrop where the air temperature was highest (approximately 280C).

The recognised range of *H. spelea* is centered on the Pilbara region of Western Australia but also includes disjunct populations in Arnhem Land and at Groote Eylandt NT (Cogger 1996, Gow 1981), some 700 to 800km from Lawn Hill. Our records suggest that this species has a more continuous distribution in the humid regions of Northern Territory than that published (e.g. Cogger 1996). Records from Lawn Hill suggest that further populations may be located in areas containing suitable habitat to the north of the Barkly Tablelands.

Morethia ruficauda ruficauda

One individual of this taxon was observed active during the day foraging at the base of small spinifex clumps (by LM) on 15th August 1995, on the rocky slope of the Island Stack. It was identified and distinguished from *M. storri* in possessing a continuous dorso-lateral stripe from just past its eye to the snout; and from *M. taeniopleura* in possessing a much brighter red on the limbs and tail.

The recognised distribution of *M. ruficauda* is extensive, with the species occurring continuously from the Queensland/Northern Territory border west to at least the Kimberley, Western Australia, in a wide range of habitats (Horner 1992, Cogger 1996). Although Ingram & Raven (1991) include this species in a list of Queensland reptiles no further information is provided and it is not represented in the collections of the Queensland Museum. There are however, confirmed records in the Northern Territory close to the Queensland border in the northern Barkly Tablelands, approximately 150 km from this record (Horner 1992).

Elseya latisternum

Snorkelling at Indian Head Falls on the Lawn Hill Creek revealed huge numbers of tortoises; more than 50 individuals could be located in approximately 30 minutes. *Elseya dentata* was abundant while *Emydura victoriana* was less common. Two *E. latisternum* were located; one adult with a carapace length of 250 mm on 17th August 1995 and one juvenile with a carapace length of 120 mm on 18th August 1995. These were distinguished from other tortoise species present by the roughly circular carapace which was markedly serrated along the hind edge. The absence of a nuchal shield and possession of pointed neck tubercles on both specimens although not diagnostic of *E. latisternum* lends further support to the identification.

On 19th August 1995 at the Riversleigh crossing of the Gregory River south of Lawn Hill another juvenile *E. latisternum* with a carapace length of 130mm and a width of

120 mm was caught while snorkeling.

The distribution map in Cogger (1992) suggests that this species is largely restricted to drainage basins on the eastern slopes of the Great Dividing Range as is indicated by specimen records from the Queensland Museum (Ingram & Raven 1991). However just four years later the range of *E. latisternum* (Cogger 1996), has been greatly expanded to extend across the lower catchments of all rivers flowing into the Gulf of Carpentaria, with additional records from the Kakadu National Park region NT. The records at Lawn Hill provide a further range extension inland and suggests that the current distribution of *E. latisternum* is poorly understood. As herpetologists with an interest in the Chelidae visit more areas in northern Australia, it is likely that this species will be shown to have a more extensive range than is currently recognised.

Our observations of *E. latisternum* suggest that it occurs at markedly lower densities than other Chelidae encountered in the region. Given the presence of Estuarine Crocodiles (*Crocodylus porosus*) in many of the rivers to the north and east of Lawn Hill snorkeling in these waterways may be rarely undertaken, while other methods of Chelidae sampling may not detect species occurring at low densities. Indeed the absence of Estuarine Crocodiles in the Lawn Hill Gorge provides an excellent opportunity to study the aquatic herpetofauna of the region in relative safety.

Gehyra nana

An individual tentatively identified as belonging to this species was recorded on 17th August 1995 active at night at the foot of a rocky spinifex covered ridge approximately 500 m south of the Lawn Hill NP rangers station. This species had been encountered by the authors in June/July 1995 in rocky areas in the Top End, NT where specimens were located at various sites in Kakadu National Park and at Kintore Caves 5 km north of Katherine, NT. Our previous experience with the species lead us to identify the individual

located at Lawn Hill as an adult *G. nana* by its distinctive pattern and small adult size. LM has found that the head length/body length ratio (adults have relatively small heads, while juveniles have large, often disproportionate, heads) is a useful way of ageing *Gehyra* sp. In this instance LM considered the individual to be an adult as the head was relatively small. Although juvenile *G. borroloola* may be confused with adult *G. nana*, in this instance, the estimated age of the specimen makes this unlikely. Nevertheless this record remains tentative, as the character useful in separating these two species (the number of sub-digital lamellae) was not noted.

Despite the published ranges of *G. nana* suggesting two disjunct populations, neither of which embrace the Lawn Hill district (Wilson & Knowles 1989, Cogger 1996) its presence is also confirmed by at least two specimens from this region held by the Queensland Museum (Ingram & Raven 1991).

CONCLUSION

The general paucity of reptile surveys in the Queensland Gulf region (see Ingram & Raven 1991 p.9) may explain the high number of unexpected reptile species we encountered at Lawn Hill. Information gathered during such reptile surveys is almost certainly the primary source of information for the production of range maps in many popular reptile identification guides used by amateur and professional herpetologists alike. However in areas where survey effort has been limited, these identification guides appear to have falsely interpreted an 'absence of evidence as evidence of an absence'. In light of this, the likelihood of herpetologists locating additional species outside of their published distributions in this region remains high. Thus visitors to Lawn Hill National Park and surrounds would be well advised to carefully identify and take field notes on any unusual reptiles encountered.

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Table 1. Reptiles observed at Lawn Hill National Park, Queensland between the 14th and 18th of August 1995.

Species observed	Comments
<i>Elseya dentata</i>	Abundant.
<i>Elseya latisternum</i>	Range confirmation discussed in text.
<i>Emydura victoriana</i>	Common. Yellow and red faced morphs
<i>Gehyra borroloola</i>	Range extension discussed in text.
<i>Gehyra nana</i>	Range confirmation discussed in text.
<i>Gehyra variegata</i>	Common.
<i>Heteronotia binoei</i>	Typical form. Discussed in text.
<i>Heteronotia spelea</i>	Range extension discussed in text.
<i>Oedura marmorata</i>	Several observed at night.
<i>Ctenophorus caudicinctus macropus</i>	Uncommon.
<i>Lophognathus gilberti</i>	Common in riparian habitat.
<i>Ctenotus robustus</i>	Common.
<i>Morethia ruficauda ruficauda</i>	Range extension discussed in text.
<i>Acrochordus arafurae</i>	Several below Indari falls.
<i>Furina ornata</i>	One with a TL of 296 mm.
<i>Liasis childreni</i>	One juvenile observed

NOTES ON CAPTIVE CARE AND REPRODUCTION OF THE SHORT NOSED SNAKE (*ELAPOGNATHUS MINOR*) ELAPIDAE: SERPENTES.

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INTRODUCTION

The Short-nosed snake is a small greyish viviparous elapid with yellow to orange belly. It has relatively large eyes and a long tail which can be up to 36.4% of the snout-vent length (Storr *et al.* 1986). It occurs in the deep temperate lower south west of Western Australia. Although known to science for over a century, its biology and ecology are poorly documented (Wilson and Knowles 1988).

Compared with most other Australian elapids, *E.minor* is known from few specimens. Since its description over 130 years ago (Gunther 1863), only 24 animals have been lodged in the Western Australian Museum (WAM). The most recent additions to the WAM collection are 5 specimens from the 1960's, 5 from 1970's, 3 from 1980's and 4 from 1990's (two of which are captive born neonates).

Over the years *E.minor* has gone by several common names. Originally Krefft (1869) called it the "desert snake", then Kinghorn (1929) changed this to "little desert snake". Later, Glauert (1957) suggested "little brown snake" which was used by Gow (1983). Then Storr *et al.* (1986) called it the "short nosed snake", and other authors like Wilson and Knowles (1988) opted to go without a common name. I was amused when my permit arrived in the post allowing me to collect the "south-western tree snake".

The short-nosed snake is elusive. This may be attributable to several factors. It seems to be quite sparsely and patchily distributed, is a small greyish species, is alert, timid and is quick to retreat into dense tussock and heath vegetation - its preferred habitat (Wilson and Knowles 1988).

It was not until after about ten field trips and a fair amount of investigative work that I finally secured a male Short-nosed snake for study in captivity. My permit to keep this species also includes two females which were later captured from the same locality as the male. Both females were gravid when captured.

I have maintained this species in captivity since November 1996. In addition to the three wild caught adults mentioned, I am rearing the young of two litters born in captivity. These litters are the result of matings in the wild prior to capture. In August 1997 I observed copulation in the captive adults.

Conservation Status

Although *E.minor* is not gazetted in the WA Wildlife Conservation Act as threatened, it has been listed in the Australian Nature Conservation Agency (ANCA) Action Plan for Australian Reptiles (1993) as "vulnerable". This status is based on this snake's very restricted distribution, the paucity of recent museum records, and the potential for habitat destruction and competition with the more abundant Crowned Snake (*Drysdalia coronata*).

The fact that the ecology of *E.minor* is so poorly studied implies that this vulnerable status is based only on reasonable assumption. As the ANCA Action Plan points out, detailed knowledge of this snake's ecology is required in order to manage and conserve this species.

Housing and Heating

The three adult snakes (Table 1) are housed separately in small glass terraria with the diagonal measurement about equal to the snake's total length (about 38cm). Large wire-covered holes in cage lids provide ventilation. Substrate is kept simple - newspaper

and paper towel, and cage furnishings include bark for shelter and sedge for basking. Adults and juveniles are proficient climbers of sedge.

Heating is provided by a 15 watt globe installed in the lid of each cage. This provides a thermal gradient of about 23-32°C and allows the snakes to climb and bask on sedge directly below the globe, no ultraviolet source is provided. A timer is used to adjust the photoperiod depending on seasonal temperature variation. During winter I provide 8 to 10 hours of light (occasionally reversed to night time during very cold weather to avoid very cold night minimums). With this reversed photoperiod, the "night" minimum (actually day) will drop to about 15°C. To some extent the use of very low wattage globes probably simulates the low light intensity and mild temperatures of the temperate south-west where these snakes occur. It is hoped that by allowing the winter night minimum to drop to about 15°C, I am, to some extent providing the snakes with enough seasonal temperature fluctuation to stimulate reproductive activity. During Perth's hot summer days I use an air conditioner with timer on during the day to maintain ambient diurnal temperature of the room at 20-25°C. With both the air conditioner and terraria lights off at night, the ambient room temperature reaches about 28°C.

The juveniles are housed in plastic boxes with volume of 900cm³ and with well ventilated lids. Cage furnishings are similar to those for adults. Heating is provided by electric blanket to warm the cage floor. In summer, the electric blanket setting is reduced or switched off allowing the cage temperature to fluctuate with the ambient temperature. At these times there would be almost no thermogradient, and although this situation is not the optimum temperature conditions, the juveniles appear healthy, feed well and grow. See Table 3 showing neonate growth data.

The adult snakes often flatten the portion of the body directly below the heat source to maximise heat absorption. The non-reflective

(matt) appearance of the dorsal and lateral scales of *E.minor* would also assist in this.

Water is provided constantly. The results of unpublished work by Graham Thompson on the relationship between morphology, metabolism and evaporative water loss in reptiles indicate that *E.minor* neonates have a comparatively high rate of evaporative water loss. It would seem therefore that this species is particularly dependant on moisture and humidity compared to other elapids. The association of *E.minor* with swampy habitats would seem to support Dr Thompson's findings.

Feeding

Frogs are the main food item taken by the captive snakes. Frog species readily taken include *Litoria adelaidensis*, *Crinia georgiana* and *C.insignifera*. Euthanased frogs are bulk frozen and thawed as required. Thawed frogs placed in snake cages require a few drops of water as they tend to desiccate very quickly. Placing the thawed frog in a plastic dish, off the absorbent paper substrate, also helps keep meals clean and moist. Tadpoles and fish (*Gambusia affinis*) have been eaten occasionally. These were placed in the snakes' water bowls live.

Captives are very alert hunters and foragers. They will actively search the cage to locate live or thawed frogs. Live frogs are often located by movement and pursued with short burst of speed. *E.minor* seem quite *Demansia* - like in their hunting behaviour. The large eyes of this snake may reflect their importance for the visual detection of prey. The two female snakes (table 2) continued to feed while they were gravid

Shine (1985) identified skinks and *Crinia* frogs as food items in dissected museum animals, but I have not been successful in persuading these snakes to accept lizards. Lizards offered included live *Hemiergis peronii*, *Cryptoblepharus plagioccephalus*, small *Ctenotus labillardieri* and *Christinus marmoratus*. All these lizards occur within the distribution of *E.minor*.

One frog species rejected as food was a small *Litoria moorei* which one snake bit on the head and promptly "spat" out. Presumably this frog species exudes a distasteful sub-

stance for deterring some predators. New born mice scented with "frog juice" did not appear to interest the snakes in the slightest.

Morphometrics of Adult snakes

Table 1. Length, Mass and Scalation recorded soon after capture.

Sex	Total Length (mm)	SVL (mm)	Tail % SVL	Mass at Capture (g)	Subcaudals	Ventrals
#1 male	376	280	34.3	10	57	121
#2 female	390	305	27.9	19	53	131
#3 female	413	323	27.9	24	51	123

Sexing by cloacal probe showed 6 mm penetration in the male and 1-2 mm in each of the females.

Parturition Data

Table 2. Reproductive effort was calculated as (100 X mass of litter/female mass after parturition).

	Adult Females	
	#2	#3
Mass of female (g)	31.4	34.0
Pre-parturition		
Weight Loss of Female (g)	9.4	12.6
Post-parturition		
%Weight Loss of female	29.9	37.1
Post-parturition		
%Reproductive Effort	27.3	36.9
Mass of Litter (g)	6.0	7.9
Litter number	5	8
Pre-parturition slough	20 days	29 days
	Neonates	
Date of birth	16/1/97	16/1/97
Mass Average (g)	1.2	1.0
SVL Average (mm)	112.8	106.6

Reproduction

Shine (1986) recorded litters of 8, 9 and 12, based on the number of oviductal embryos or enlarged ovarian follicles in the preserved specimens which he examined. These data compare with results in Table 2 of 5 and 8 based on neonates at birth. Shine also recorded a full-term oviductal embryo with a SVL measuring 89 mm. This compares with 109 mm SVL averaged for my 13 neonates at birth. Given that there have only been five litters documented for *E.minor*, with only two of these litters recorded at birth, the above comparisons are inconclusive but do contribute to a poorly lacking data set for this species.

Bush (1992) documents parturition dates for five other species of viviparous snakes occurring in the lower south west of WA: *Drysdalia coronata*, *D.mastersii*, *Echiopsis curta*, *Notechis scutatus occidentalis* and *Rhinoplocephalus nigriceps*. He recorded parturition between March and April. The two litters of *E.minor* recorded by myself were born in mid January. It appears therefore that *E.minor*

breeds considerably earlier (about two months) than comparable elapid snakes. It is doubtful that the partial captive gestation of these two *E.minor* litters could have accelerated development and parturition. Supporting this is a specimen in the Western Australian Museum collection which was collected in January 1978 having well developed oviductal embryos.

The reason why *E.minor* might be an "earlier breeder" might be linked to the seasonal breeding of the small Myobatrachid frog species on which this snake feeds. Field work needs to be conducted on the reproductive cycles of prey frogs and *E.minor* to support this.

There was no post-natal sloughing of the young in either litter, however one neonate slough was found in the cage at birth. The neonates commenced feeding at 1 week old and they did not show their first pre-slough condition until 43 days old. All neonates had sloughed by 56 days old. They were all weaned from live frogs to thawed frogs by 72 days old.

Growth

Table 3. Neonate Growth Data. Neonates #3 and #12 died soon after birth.

	Female #2					Female #3								
Neonates	1	2	3	4	5	6	7	8	9	10	11	12	13	Average
Mass @ Birth (g)	1.2	1.1	1.2	1.2	1.3	0.9	1.1	1.1	1.1	1.0	0.9	0.9	0.9	1.07
Mass @ 213 days old (g)	4.8	5.0	-	5.7	6.5	5.7	4.6	7.2	5.2	5.2	6.0	-	6.1	5.13
% Mass increase @213 days old	300	355	-	375	400	533	318	555	375	410	567	-	578	433
SVL @ Birth (mm)	113	109	112	113	117	102	110	108	108	108	103	106	108	109
SVL @ 213 days old (mm)	182	182	-	193	212	190	180	223	202	191	206	-	202	197
%SVL increase @213 days old	61	70	-	71	81	86	64	106	87	77	100	-	87	80.9

The average mass increase at 213 days represents an average of 66 small *Crinia* frogs eaten per snake or one frog eaten per 3.2 days. I suspect that the growth rates of these captive juveniles is lower than the wild situation. Initially the neonate snakes were fed *Crinia* frogs weighing 0.1 - 0.3 g. During mid to late summer frogs of this size can be very abundant in southwestern W.A. following average to high winter rainfall. Young *E.minor* in the wild would have the opportunity to eat plenty of these at this time of year. The rationed feeding in this study was due to low frog supplies at times.

Ontogenic Colour change

At birth *E.minor* has striking colouration (see Figures 1-4). At maturity the most obvious colour changes occur on the head, belly and tail. Juveniles have a distinct white face, orange collar, orange lateral zones on belly and red tail. In adults the face darkens to pale grey and becomes less distinct. The collar is reduced in length and fades to pale yellow. The orange flush on the belly is greatly reduced and the tail loses the red colour becoming grey with a brownish tip.

Copulation Behaviour

I did not give the male(#1) access to female #3 as I did not consider her to be of adequate health to breed. She had parasitic worms and was not putting weight back on after her previous litter of 8 young.

On 2 March 97 the male was interested in female #2, but she was not receptive. On 15 May 97 the male was interested in female #2 but she retreated quickly from his advances. On 12 August 97 copulation was observed within minutes of introducing the male into cage of female #2. Pre-copulation behaviour included the male rubbing his chin over the female's anterior dorsal surface. Copulation commenced at 2:20pm and lasted for 2.5 hours during which the male would often wiggle his tail and move his tail in a spasmodic or pulsing motion. The cage thermogradient was 23-32°C. After copulation, the male was removed from her cage and she entered the

water bowl, soaking her body for several hours. She stopped soaking briefly to feed on frogs offered. Soaking was also observed for at least 12 hours of the following day.

Parasites

Nematode worms have been found in faeces and on regurgitated frog of two adult snakes. These round worms were identified as *Ophidascaris* sp. Treatment with Panacur injected into thawed frog prior to feeding snakes, and freezing of frogs seems to have controlled the nematode problem.

More recently, flukes have appeared in the faeces of one adult female. This same snake gave birth in January, after which she began to pass the *ophidascaris* worms. She also developed a distinct swelling in the fore body and became very subdued five days after parturition, but I am unsure whether this was due to the parasites, the trauma of giving birth or some other reason. Although the swelling subsequently disappeared and the snake is no longer passing nematodes, she has not put back on the condition lost after giving birth, unlike the other female (26 V, 40 grams respectively on 13 August 97). The flukes may explain the lack of weight gain in this female.

Bearing in mind that this species has a preference for frogs, endoparasitic worms are expected. Perhaps by feeding these snakes only thawed frogs, the worm problems would be minimal.

Remarks

As with many Australian elapid snakes, the Short-nosed snake is easily maintained under captive conditions provided the basics are carefully met. Although initially timid, they are very docile, quite active and diurnal in captivity.

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Figure 1: A juvenile *E.minor*



Figure 2: Juvenile *E.minor* ventral colouration

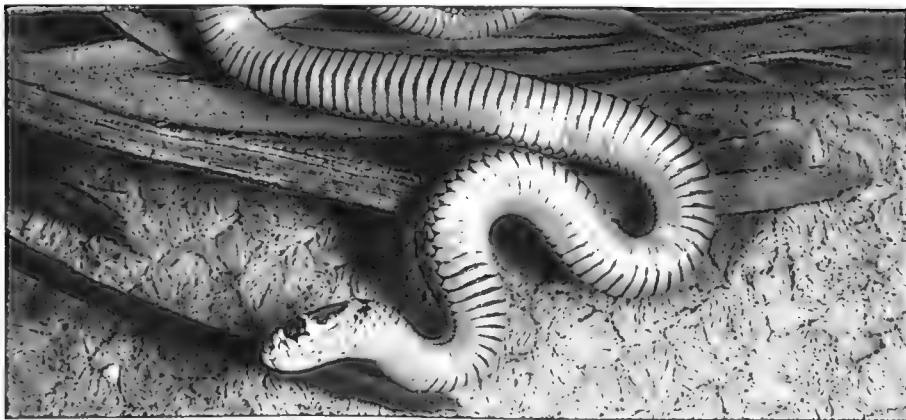


Figure 3: Adult female *E.minor*

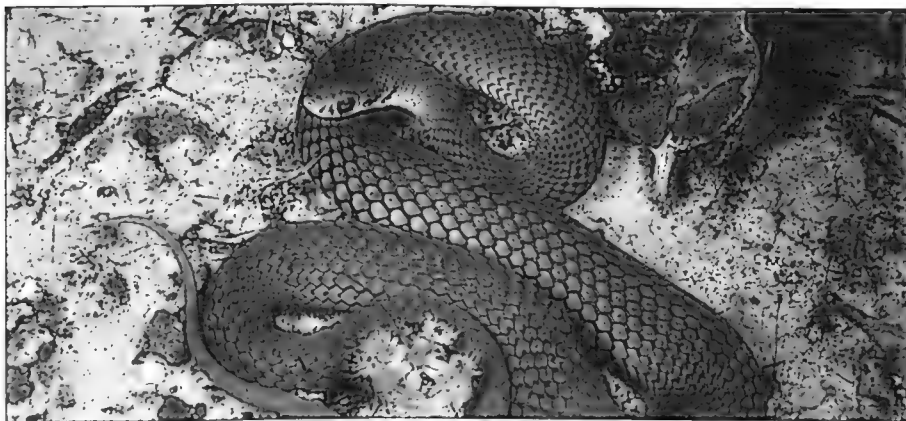
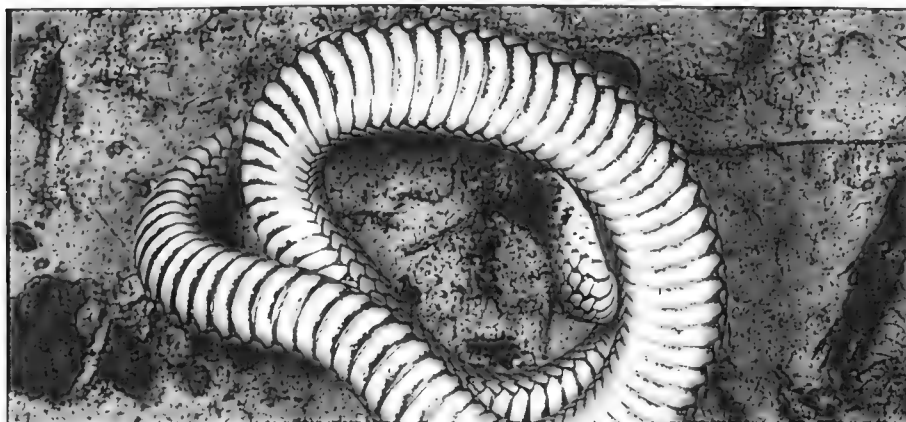


Figure 4: Adult female *E.minor* ventral colouration



SEASONAL AND MICROHABITAT PARTITIONING OF CALLING SITES BY FROGS FROM SOUTHEASTERN QUEENSLAND.

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ABSTRACT

I recorded seasonal changes and microhabitat utilization of a series of frogs from a variety of habitats in southeastern Queensland, Australia. I compare these data with original and published information on seasonality of frogs from Victoria. *Crinia signifera* bred early in the austral reproductive year associated with its preference for colder temperatures. Several species bred in September with the onset of warm spring rains, but others waited for the warm, mid-summer rains of the "wet". The number and kind of species present at study sites differed with habitat, though some species occurred in a wide variety of habitats. Within a habitat, different species of frogs had different calling sites so that habitats were partitioned both seasonally and by microhabitat call site preferences.

Species diversity was greatest in open and pasture ponds and along streams in sclerophyll forest and lowest in the cool, seasonally dry, montane cloud forests. In 1983 population levels of all species was low and the number of females and number of matings few. The low populations may be due to habitat destruction, but more likely are due to the drought in Australia in the years prior to 1983. Many 1983 sites had been altered or destroyed when observed in 1993.

INTRODUCTION

In order to reduce competition, avoid predation, and to find food and shelter, animals space themselves throughout their environment into many microhabitats and niches (Duellman and Wild, 1993; Toft, 1980; Inger, Voris, and Frogner, 1986; Vitt and de Carvalho, 1995). These constraints increase during reproductive periods with the requirement on

the one hand to advertise for and/or seek out a mate and on the other hand to protect eggs and young (Gregory, 1979; Hinshaw and Sullivan, 1990; Resetarits and Wilbur, 1989, 1991; Villa, McDiarmid, and Gallardo, 1982). Amphibians, especially those in arid and tropical regions, have developed a gamut of reproductive modes to accomplish this (Crump, 1974; Duellman and Trueb, 1986; Wells, 1977). Calling male frogs advertise and this may attract predators and social parasites (Haddad, 1991). Frogs of different species utilize different call sites, space their calling sites, have different call characteristics, and utilize different habitats and microhabitats (Duellman, 1967; Duellman and Pyles, 1983; Etges, 1987; Penna and Veloso, 1990; Townsend, 1989). In addition to spatial and frequency separation, Littlejohn (1965) mentions temporal separation of species which includes calling at different intervals, different times of the night, and at different seasons. Call sites should be selected by males to attract females in the best way acoustically (Blackwell and Passmore, 1990; Townsend, 1989). Since amphibians are tied to their thermal environment (Brattstrom, 1963) for activity and timing of reproduction, and since individual thermal responses are usually dependent upon frog size, and since frogs respond differently to temperature and rainfall, there is often a seasonal succession of amphibians in the same reproduction habitats (Dixon and Heyer, 1968; Heyer, McDiarmid, and Weigmann, 1975). If the seasonal succession is sufficiently spaced out and the habitat still provides water for reproduction, then individual species can breed for longer periods and competition for male call sites is reduced (Jones and Brattstrom, 1962; Resetarits and Wilbur, 1991; Williamson and

Bull, 1992; Woodward, 1982).

There are some data on microhabitat use and acoustical separation of Australian frogs (Barker, Grigg, and Tyler, 1995; Cogger, 1992; Tyler, 1989) and it is known that different species of Australian frogs have different thermal requirements and thermal limits so that Australian frogs have a seasonality of calling and reproduction. Yet there have been few studies on this seasonality on a community of frogs from the same location. Duellman and Trueb (1986) list 29 reproductive modes for anuran amphibians, yet the known reproductive strategies for Australian frogs are limited (Brattstrom, in prep; Richards and Alford, 1992). Other than terrestrial direct development by Australian Microhylids and foam nests by some Leptodactylids, specialized reproductive modes consist of raising eggs and tadpoles in the stomach, in lateral pouches, and constructing water filled basins (Richards and Alford, 1992). This suggests that, in the absence of more reproductive specializations, there is increased pressure for Australian frogs to use different habitats and to utilize these habitats chronologically or seasonally. I record here seasonal changes and microhabitat utilization of a series of frogs from southeast Queensland. I compare these data with original and published information on seasonality of frogs from Victoria.

MATERIALS AND METHODS

The study area was located about 100 km north of Brisbane, Queensland. Study sites (Fig. 1) were numerous ponds, streams, swamps, rivers, and artificial cement ponds and cisterns located in the vicinity of the small town of Maleny and on the roads to the north and north west. Study sites were visited at least once every two weeks, often more frequently, from 1 August to 29 December, 1983. Time on specific study sites ranged from a few minutes to several hours depending upon whether frogs were present and the size and complexity of the area. Main study areas were the Montville Road ponds, the

Mary Cairncross "rainforest" reserve, and along the road to, and at, Borumba Dam. At each site the species of calling frogs were listed. Sketches were made of the habitat and where each species was calling. Photos of habitats, study sites, and frogs, were taken and verification tape recordings were made. General climatic conditions for the area are described by Arthington, (1988). Temperatures, recorded for Nambour, a low elevation station (Fig. 1), ranged from 7° to 37.5° C and the rainfall for the 1983 chronological year was 1253 mm. The elevated, volcanic Maleny area is at 600-700M elevation and is subject to fog and orographic rainfall. The more open and inland Conondale area is in a low open valley so temperatures for study sites in this area were probably colder and rainfall more varied. Habitats ranged from open farm or pasture ponds in former montane rainforest, often with a few dairy cattle (Montville Road Ponds), to ponds, streams and rivers, in pastures, grazed open fields, mesic or dry sclerophyll forests dominated by *Eucalyptus* and *Acacia* (Conondale to Yabba Creek, Kenilworth to Mapleton area), to Montane rainforest reserves (Mary Cairncross, Kenilworth). The latter are called tropical rainforests, but they are in fact dry for long periods, cold in winter, and have low vertebrate species diversities (Brattstrom, 1992). One of the study sites at Borumba Dam had both a small natural pond within a cultivated park and an open cement water lily pond in the middle of an open grassy area. When observed 10 years later in 1993 the cement pond at Borumba had been filled in and the small pond destroyed. The Maleny-Montville Ponds in 1993 were reduced in size, partially filled, and surrounded by houses on 1 to 2ha. lots. Obi Obi Creek is now dammed and outflows into the Mary River (habitat of platypus and lungfish) are controlled and limited. More and new introduced weeds occur in all but the Mary Cairncross Park, and cattle grazing and "controlled" burning continues in 1993 as it had in 1983.

The introduced and naturalized *Bufo marinus* was present throughout the study area (in Monterey Pine, *Pinus radiata*, plantations, cattle and farm ponds, about houses, in native forests) but not in the dense montane forests such as Mary Cairncross. This toad usually bred in polluted, contaminated, or non-natural situations which were not utilized by native frogs. Except for special situations where native frogs were present (Montville Road Ponds, Borumba) it is not included in the following descriptions.

While the study was done in 1983 and for only 5 months, general observations and some thermal data were obtained throughout the year in 1966-67 in Victoria, Queensland, and New South Wales, and on the study site and in Northern Queensland, August to January, 1993. Thermal data presented in Figure 2 and 3 are original or from the literature (mostly Brattstrom, 1970; Main, et al, 1959; Tyler, 1989).

RESULTS

Figure 2 shows the chronology of breeding times of frogs in the Maleny area from this study and data for these frogs in Queensland from the literature. Note that such species as *Crinia signifera* breed early in the year and cease breeding early due to the preference of this species for colder temperatures (Williamson and Bull, 1992). Several species start to breed in September with the onset of warm spring rains, still others, such as *Litoria caerulea*, *chloris*, and *rothi*, wait for the warmer weather and rainfall associated with the mid-summer and onset of the monsoonal "wet". Note, also, that the onset of breeding is correlated with an increase in minimum water temperature. As expected, early season frogs also have low critical thermal maximum temperatures while those of late breeding frogs are higher (Brattstrom, 1970).

Figure 3 shows data similar to Figure 2 for frogs from the southeastern state of Victoria.

Note that, while there are early and late breeders and that the onset of breeding correlates with minimum water temperatures, breeding in Victoria starts in the late autumn with the beginning of autumn-winter rains and often ends earlier in the spring. Note also, that the time of breeding for species that occur in both areas may be earlier (*Crinia signifera*) or at about the same time (*Limnodynastes peroni*) though the minimum temperature of the water for each species is the same (4° for *C. signifera*, 9° vs 10° for *L. peroni*), *Litoria peroni* breeds much later in the year in Victoria than in Queensland due to the slow rate of spring warming in Victoria. Some species have relatively long reproductive periods while others have short periods. The heavy rainfalls of the monsoonal "wet" (Jan/Mar) and/or the onset of the dry period usually ends breeding.

Figures 4-7 show microhabitat use by calling males of several species of anurans at several locations and for several dates. Some species occur only at certain sites, while others are found at several sites. *Crinia signifera* was found at Yabba Creek, along the Mary River and in shallow streams and ponds in the Maleny area. *Litoria latopalmata* was found calling from within tall grass just away from slow moving streams in open cleared fields. *Assa darlingtoni* (not shown in figures) called only from the tallus slopes of the Icehouse Mountains area (Fig. 1) and *Mixophyes* was found only in the Mary Cairncross montane forest area. Other species such as *Litoria fallax* and *Limnodynastes peroni* were found in a variety of sites. *Litoria fallax*, *caerulea*, *lesueuri*, *verreauxi*, *nasuta*, *Limnodynastes peroni*, and *Bufo marinus* were commonly seen on or near roads going to and coming from breeding sites; others were rarely seen on the roads. No *Pseudophryne* sp. nor *Litoria pearsoniana* were seen.

At the Borumba Dam (Fig. 4) male *Litoria peroni* called from 3-5m up in small trees or in

the open, middle portions of a large cement lily pond. *Litoria fallax* and *Limnodynastes peroni* called from, respectively, lily pads throughout the pond and under lily pads primarily near the edge of the pond. By December 15, *Limnodynastes peroni* was not calling at this site and only a few called at other sites. By November, *Litoria rubella* was observed, early in the evening, emerging from within cracks in a cement block wall surrounding a nearby toilet block and could be observed hopping over the mowed lawn to calling sites in tall (3m) grass at the edge of the cement pond. *Bufo marinus* and *Litoria caerulea* were only observed in this pond in December. *Bufo marinus* emerged from cracks and crevices in the ground associated with pond plumbing or drains. *Litoria caerulea* emerged from cracks, pipes, and cisterns in the toilet block area. On October 29, *Litoria latopalmata* was calling from the cut grass at the edge of the pond. These thin, quick frogs sound like quacking ducks and quickly escape into the water of the pond when disturbed. On November 22, from the same microhabitat, at Borumba Dam, I heard thin, quacking frogs that jumped into the water when disturbed. The quack call was slightly higher pitched. At first I ascribed this to the effect of the warmer air temperatures that night. However, I found that on this date the quacking frog, in the same microhabitat, was *Litoria nasuta*. No *Litoria latopalmata* were seen. This suggests that the best acoustical place for a frog that quacks is an open area and in consequence the frog must be able to escape rapidly into the water. Neither species was present at Borumba Dam later in the year. Both species called for several more weeks at other sites, with *Litoria latopalmata* calling earlier and leaving sooner than *Litoria nasuta*. Compared to other species both have a short breeding season (Fig. 2) with one species replacing the other. On November 22, *Litoria nasuta* was also calling from nearby streams while *Litoria lesueuri* called in these streams earlier in the year (October and early Novem-

ber).

Figure 5 shows microhabitat and seasonal use of the Maleny-Montville Road ponds. Some of the changes observed were seasonally associated with temperature and rainfall, while others, especially local movement of individual species to shallow or deeper water, were associated with changes in the size of the ponds. *Crinia signifera* called from flooded (5-100mm) grass at the edge of both of the large ponds early in the year (see diagram for October 13). *Litoria fallax* called from the tops of lily pads throughout the season, but shifted away from the edges of the ponds, when the ponds were low (i.e. December 3). *Litoria nasuta* and *Bufo marinus* were only at these ponds in December; *Litoria nasuta* near the edge of ponds and along a partly submerged fence and *Bufo marinus* in deeper water, but near the edge of the pond where the pond edge was abrupt. The sibling species *Litoria peroni* and *tyleri* were sympatric in these ponds, but were distinct in their very different calls and for the most part were in slightly differing habitats. *Litoria peroni* was usually in deeper water and called from lily pads or projecting tree stumps. With seasonal and microhabitat utilization and marked differences in call characteristics, all these species used these ponds with no apparent interaction. Population numbers of *B. marinus*, *Litoria peroni*, *Litoria tyleri* were low (letters on diagrams in Fig. 5 actually show number of individuals) and so competition between males might be low due to low population levels or the low populations may be due to previous drought conditions and absence of food. *Litoria fallax*, *Crinia* and *Litoria nasuta* were abundant and fairly evenly spaced throughout the habitat they used. Early in the evening *Litoria fallax* were observed fighting and giving challenge calls. This resulted in *Litoria fallax* being spaced on lily pads about .5-1m apart. *Limnodynastes peroni* called from small tent-like openings within tall, partly submerged grass (.5-1m)

especially in the deep water on either side of a partly submerged fence. The frogs made their pop-it or exploding bubble-like calls from within the grass clump but facing out toward open water as from within the entrance to a tent. Males were submerged with body and legs dangling down in the water at a 45 degree angle, arms and/or legs bracing the frog against the grass. The head and vocal sac, or the top half of the head and vocal sac were above water. Females approached males and (on two occasions) came up from under the water in front of the male. The male clasped the female and mating occurred. Foam nests resulting from the mating were on top of the water but within the grass clump, occasionally on one or sometimes both sides of the "tent" opening. *Limnodynastes peroni* males were often calling within 20cm. of each other (though most were spaced about 1m apart). In a small 10 x 3m area of 20 concentrated, calling *Limnodynastes peroni*; foam nests were found primarily around three calling males. One of these males had three foam nests about his calling site. Call characteristics and evidence of successful mating may be important in female mate selection in these close situations. Except for *Limnodynastes peroni*, no other matings were observed at this location, nor were any eggs and tadpoles discovered, though *B. marinus* may have been successful here later in the year.

Limnodynastes peroni, *Litoria fallax*, and *Litoria peroni* were calling from similar microhabitats in a small pond, in a flooded, weedy pasture, north of Conondale (Fig. 6). Here *Litoria fallax* called from its typical calling site and also from the tops and sides of tall cat-tails (presumably *Typha orientalis*). *Litoria peroni* called from floating vegetation and emergent sites; here they occupied the tops of nearly submerged fence posts. Later in the year and at a site a few km to the north, *Litoria fallax* and *Limnodynastes peroni* were still calling from typical sites (Figure 6, bottom),

as they had been for most of the spring, but by December 15, *Litoria verreauxi* was calling from the bare ground along this very slowly moving creek and *Litoria latopalmata* also called from the ground, but within tall grass. When disturbed, the former jumped into the creek, and the latter jumped or crawled deeper into the grass. Typically *Limnodynastes peroni* sank down deep into the water when disturbed. *Litoria fallax* and *Limnodynastes peroni* seldom move when disturbed; at most the former jumps to another lily pad or into the water (swimming to another lily pad or to the bottom of the pond). *Litoria peroni* just stops calling and settles down on its calling site presumably relying on its very cryptic coloration. Occasionally *Limnodynastes peroni* will make a big jump into the water or to a nearby perch.

Mary Cairncross Park (Fig. 6, 7) consists of a small reserve of virgin montane cloud forest. *Ficus* and other trees with buttresses and lianas occurred along streams and in very wet, swampy areas. The tall, slender King Palm, *Archontophoenix cunninghamiana*, makes this area look like a tropical rainforest. The lack of leaf litter, the long season of low or no rainfall, cold winter temperatures, and low species diversity indicate that this is a cool, seasonally dry, montane forest (Brattstrom, 1992 and in prep.). Birds and mammals in this forest, while interesting (brush turkey, bower birds, cat birds, forest wallabies), are also low in species diversity, and have primarily cool, southern Australian biogeographic affinities (Brattstrom, 1992). The amphibian fauna is also depauperate and cool, south-temperate in origin. Only three species of amphibians occurred in this forest. *Adelotus brevis* was found only along the slow, murky, shallow stream in the middle of the reserve. Usually only 2-3 *Adelotus* called from the Palm swamp area, up to 7 called here on nights following rains. Males were spaced 10-20m apart which may have been territorial or acoustical spacing or just

the availability of the mats of clean, dry leaves and sticks. *Litoria chloris* was found calling after December 17 around a cistern at the edge of the forest and the grassy picnic area. *Mixophyes fasciolatus* (these frogs had reflected blue in their eyes and hence may be *M. fleayi*) was not seen or heard until early November when I heard males calling from underground retreats (Fig. 7). The frogs were in bare soil areas within the roots of forest trees and were evidenced by their deep calls coming from small holes (1-3 cm) on the forest floor. The holes widened a few cm from the surface, but these large frogs could not be seen when a light was beamed down the hole. Both males and females were observed moving through the forest on December 3, all heading toward the small, muddy stream. Calling male *Mixophyes* were found in only one area of this stream December 3, 13, 17 (Fig. 7). Moving and foraging *Mixophyes* were not easily disturbed and continued to hop across the forest floor even when I was close and they were in a flashlight beam. If approached within 30cm or touched, the frog would go from its alert head and body up, hopping position, to a low, crouched position, with the belly touching the substrate, but horizontal. If disturbed further, the *Mixophyes* would flatten into a hidden or cryptic position with the head and body touching the substrate, and forelegs flat against the substrate. Calling males are in a high alert stance with body almost vertical, head at a right angle, head and forepart of the body supported by nearly straight forelegs.

Adelotus and *Mixophyes* were also found in the Kenilworth rainforest. *Litoria caerulea* was found along a stream in that forest, as well, but was more common in ponds in open areas within disturbed parts of the forest or in dry, sclerophyll forest areas. The Kenilworth forest is a State Forest Reserve and surrounded for kilometers to the west and northwest by wet and dry sclerophyll forests, yet several feral house cats were found foraging in the

rainforest reserve. These monsoonal, montane forests had low numbers of species of frogs and it was the open, pasture area ponds and streams in sclerophyll forests that had the greatest diversity of frogs. Within these latter habitats, males of different species called from very different calling sites. Population levels were low, the number of females and the number of matings were few. Eggs and tadpoles were seen for only three species (*Limnodynastes peroni*, *Litoria fallax* and *B. marinus*) during the study period. The prevailing questions were: Where are all the females? Why are population levels so low? Was drought or human interference responsible?

DISCUSSION

The availability and nature of rainfall, presence of water, temperature, and rate of drying of breeding sites will all affect the onset, duration, and cessation of frog calling (Duellman, 1995). The sequences shown in figures 2 and 3 are expected to start and stop at different times from year to year, but the succession of species are expected to be in the same general order due to the importance of temperature to activity and breeding (Brattstrom, 1970). Environmental factors will also affect egg and tadpole survival (Pechman, Scott, Gibbons, and Semlitsch, 1989). The role of rainfall and temperature on Australian frog reproduction has been described by Main, Littlejohn and Lee (1959). The data in this paper extend these ideas to other areas of Australia. The shifts in pond microhabitat use associated with changes in water level as seen in the Maleny ponds are similar to those described by Dixon and Heyer (1968) and Caldwell (1986). The persistence of water and correct temperatures allow some species to prolong their breeding, especially in tropical habitats (Duellman and Wild, 1993; Woodward, 1982). In southeastern Australia, rainfall is less seasonal and the weather generally cool. *Crinia signifera*, which has seasonal breeding in the early cool part of the

year in Queensland and even parts of Victoria, is known to have longer breeding periods (March to November, with peaks July to September) near Adelaide, S.A. (Williamson and Bull, 1992) and even year long breeding 50 km south of Sydney, N.S.W. (Lemckert and Shine, 1993).

Call site selection and its acoustical and reproductive importance in mate selection and mating success has been extensively studied in the North American treefrogs, *Hyla versicolor*, *chrysoscelis*, *cinerea*, and *gratiosa* (Asquith and Altig, 1980; Fellers, 1979; Godwin and Roble, 1983; Lamb, 1987; Mitchell and Miller, 1991; Ptacek, 1992; Resetarits and Wilbur, 1989; Ritke, Babb and Ritke, 1991). That there is a genetic component in call site selection and the fact that there is competition for calling sites is suggested by the fact that hybrids between species call from sites that are intermediate from parental species, (*Hyla cinerea* and *gratiosa*; Lamb, 1987) and the fact that, in the absence of a sympatric sibling species, *Hyla versicolor* or *chrysoscelis*, use more kinds of calling sites, including those which other species use when in sympatry (Ptacek, 1992).

Acoustical spacing and territorial fighting often distribute a species of frog throughout its available habitat during the breeding season (Fellers, 1979; Perrill and Shepherd, 1989; Roithmair, 1994). Similar spacing based on sound and aggression have been described for *Crinia signifera* and *C. riparia* in Australia (Bull and Telford, 1986; Odenaal and Bull, 1986). I expected, but did not find some kind of competition or aggression between the sympatric species, *Litoria peroni* and *L. tyleri*. In spite of their similar morphology (Martin, et al, 1979), they have such distinctive calls and occupy such different calling sites (Fig. 5) that no interactions between these two species were observed: At the Borumba Dam site, my wife and I sat for many hours at different ponds watching for

the expected aggression between male *L. peroni* (Dankers, 1977). We did observe males approaching, crawling up and subsequently calling from low trees. We observed newly arriving males and territorial males engage in challenge or assertion calls (Dankers, 1977; Wells, 1977) with the challenger (the new arrival) calling from the ground or low bushes. New males usually took up a more distant calling site in the same tree and the new arrival rarely left the area. We never saw any *L. peroni* fighting. It was our impression, however, that there were many more calling sites than there were males. This is in concert with the observed low population levels of calling males of all species, the almost complete absence of females, and the absence of eggs and tadpoles in all ponds and streams (except for *Bufo marinus*, *Crinia signifera*, *Litoria fallax*, and *Limnodynastes peroni*). These low population levels may have been due to the extended drought in Australia over the last century (Saunders, et al, 1990) and especially in the years prior to 1983.

Harsh conditions, especially drought not only affect reproductive success, but also individual survival during the long dry season. Many frogs travel long distances to specific, safe, cool, wet, retreat sites (e.g. *Litoria rubella*, up to 1 km; personal observations; also see Gonser and Woolbright, 1995; McAlpin, 1995; Ward, 1987).

In some species these retreat sites are defended (Buchanan, 1992; Freda and Gonzales, 1986; Goin and Goin, 1957; Ritke and Babb, 1991; Stewart and Rand, 1991). If the availability of retreat sites is limited or inadequate, then the survivorship of frogs may be low (Stewart and Pough, 1983). With the extended drought in Australia prior to 1983, it seemed to me that populations of all species of frogs very low as compared to the years 1966-67 (Brattstrom, 1970). Unfortunately no standard survey counts were made. In addition to rocks and underground

retreats, I found many frogs, especially *Litoria rubella*, *caerulea* and *chloris*, utilizing man-made retreat sites such as cracks in buildings and stone walls, cisterns and water storage tanks. *L. caerulea* is especially famous in Australia for occurring in outhouses and toilets (especially under the rims of toilet bowls, usually only seen when the toilet is flushed! The large size and large toe pads of *L. caerulea* usually prevents the frog from being flushed away). They also occur in rain down spouts, which so magnify and reverberate their call as to bring knowing smiles to Aussie faces. Drought and the concomitant high temperatures affect not only retreat and breeding sites but also affect the amount of food, such as insects, available to the frogs, and hence result in the low populations (Donnelly, 1989 a, b). While some species of small frogs typically live only 1-2 years, *Litoria gracilentia* and *Litoria caerulea* live for 7 and 16 years respectively (Mc Annally, 1980), perhaps long enough to survive periods of drought. Continued drought, and especially harsh years (again seen in 1991-94) may be the main cause of natural frog decline in Australia (but see Laurance, *et al*, 1996; Duellman, 1995; Stewart, 1995). When this is combined with the incredible habitat destruction done by 18 million humans, 200 million sheep, 50 million cattle, 50 million rabbits (the latter number for Queensland alone), red fox, and feral cats, and in more arid areas and the 'top end' camels and water buffalo (Brattstrom, 1989, 1992; Saunders, Hopkins and Howe, 1990), it is amazing that any amphibian is successful in Australia. Conservation measures must proceed at a much more rapid pace.

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Figure 1. Map showing location of study sites in the vicinity of Maleny, Queensland. The area is about 100 km north of Brisbane.

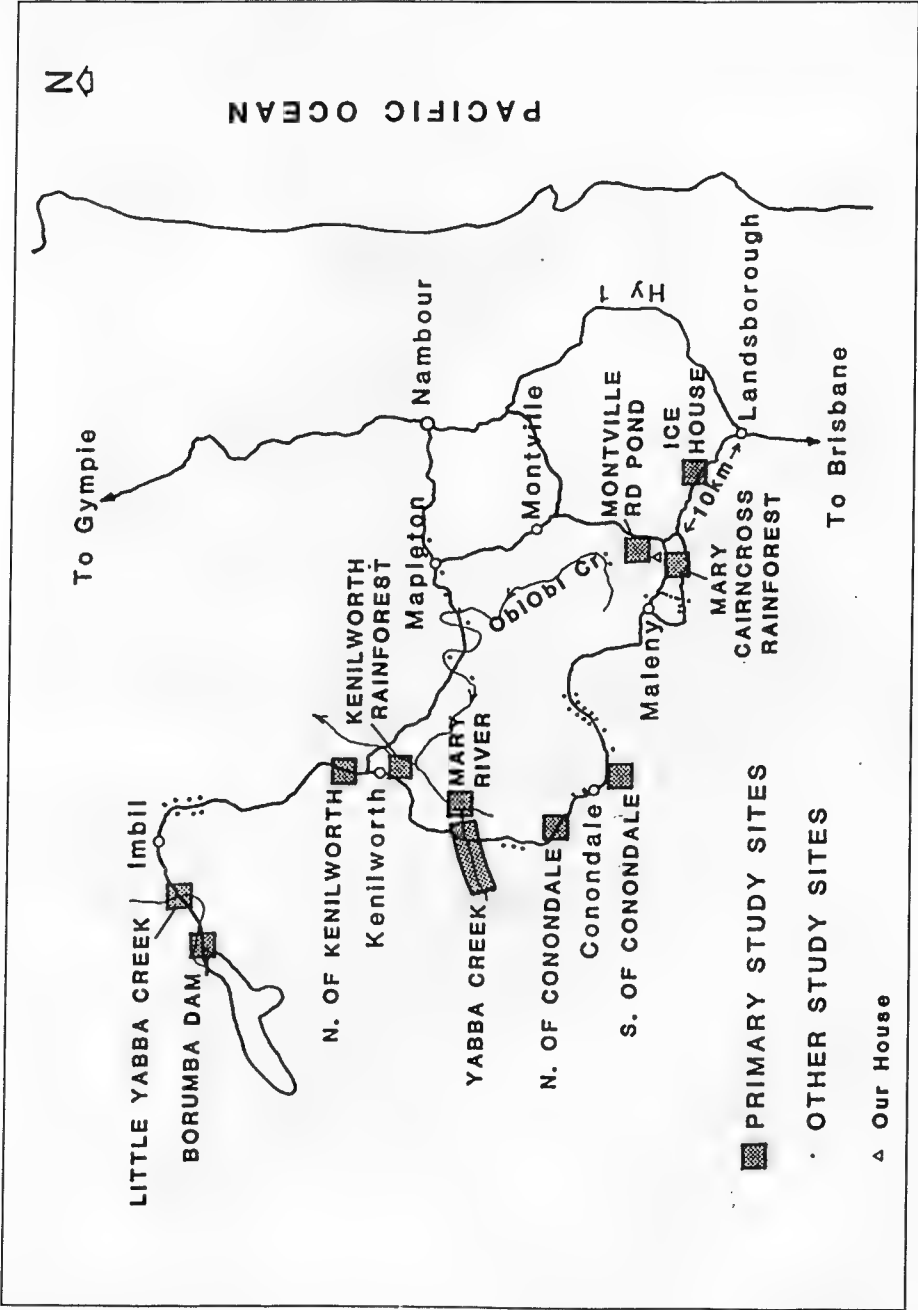


Figure 2. Breeding times of Australian frogs from the Maleny study area. Note that the year (austral mid-winter) begins in June. * probably breeds longer based on the literature or observations of the species elsewhere; ? It is not clear if the species breeds longer in the Maleny area. Thermal data are original or from the literature. The *Mixophyes* had blue reflection in its eye and hence may be *M. fleayi*.

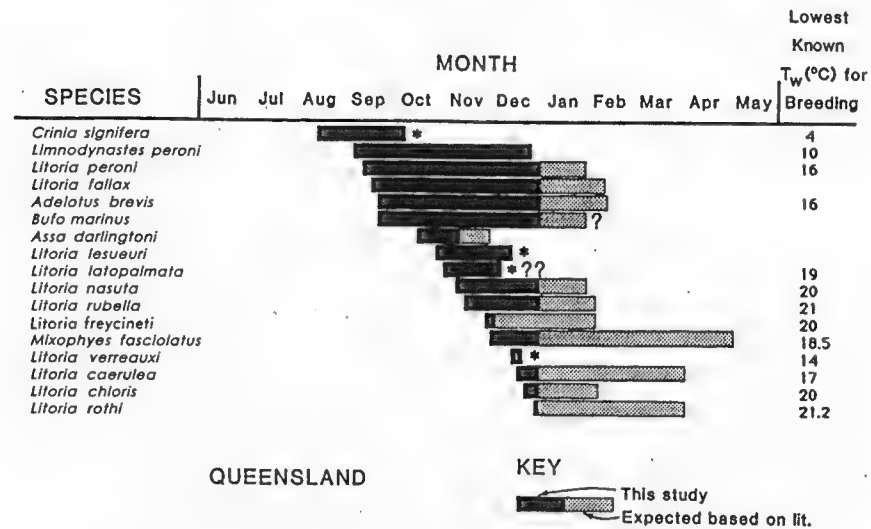


Figure 3. Breeding times of Australian frogs from Victoria. Original 1966-67 data and the literature; * indicates that the data included for *Limnodynastes peroni* are for Victoria populations only. Note that the breeding year begins in the austral autumn. *Limnodynastes "dorsalis"* is now *L. dumerilii*.

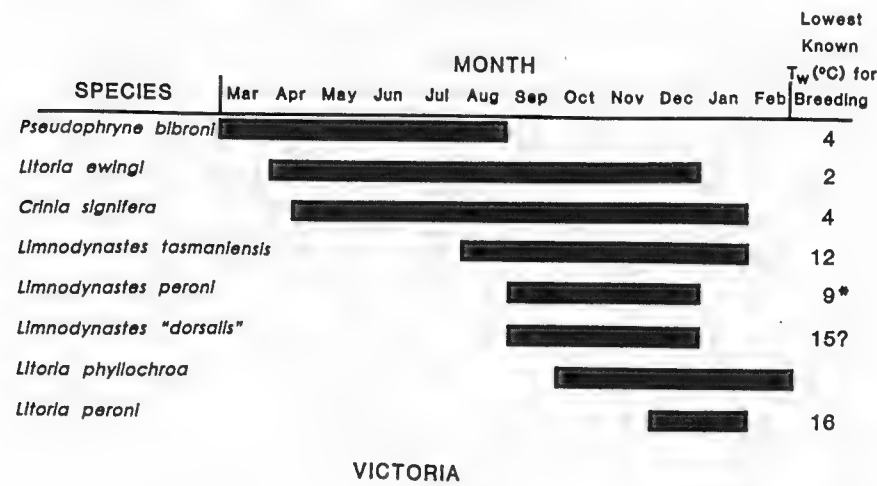


Figure 4. Microhabitat use by frogs at the Borumba Dam cement pond site for several dates.

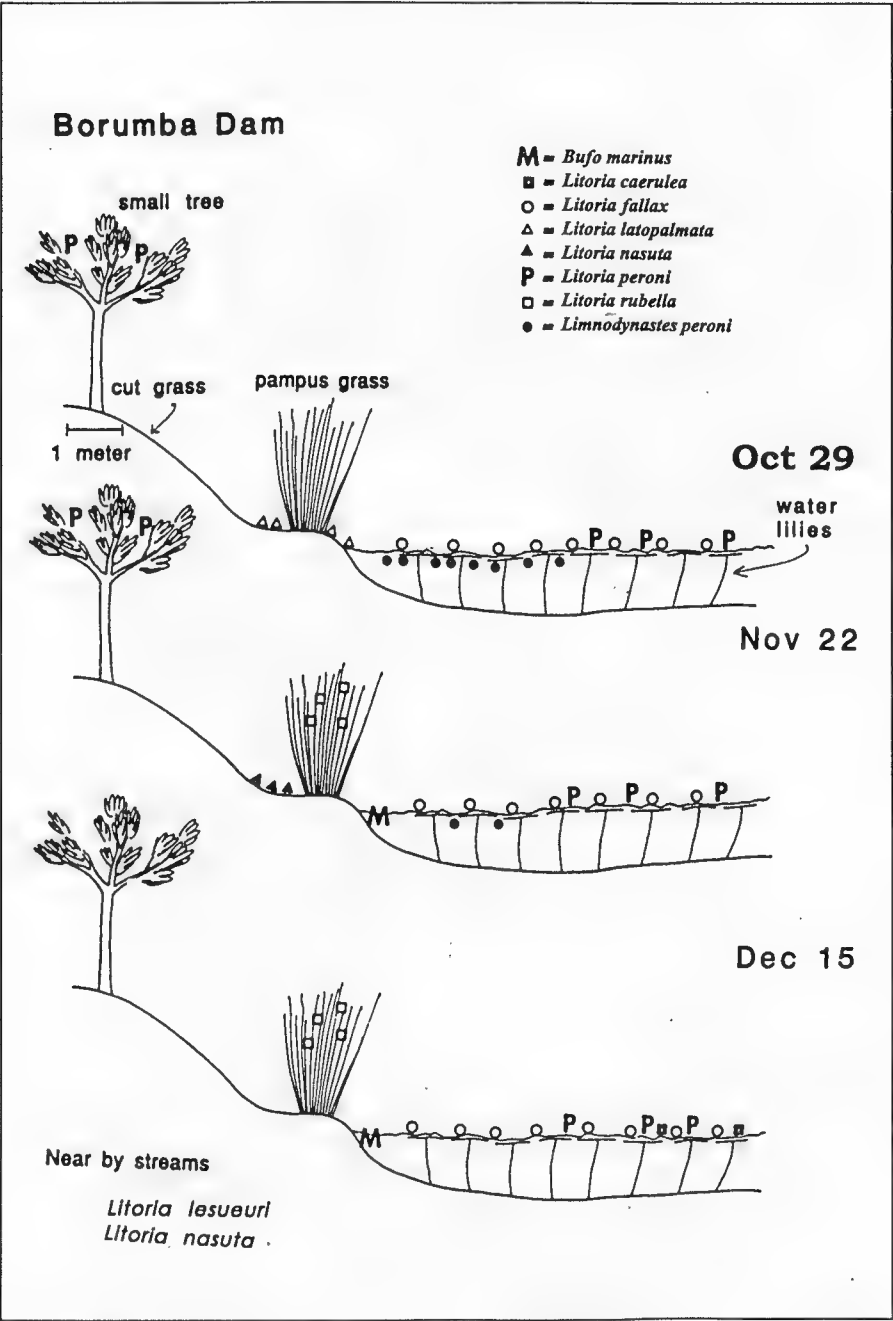


Figure 5. Microhabitats used by frogs at the Maleny-Montville Road ponds for several dates. Note that some species of frogs distribution may be by symbols and by cross hatching. Diagrams on left are cross sections at A-B on diagrams on right.

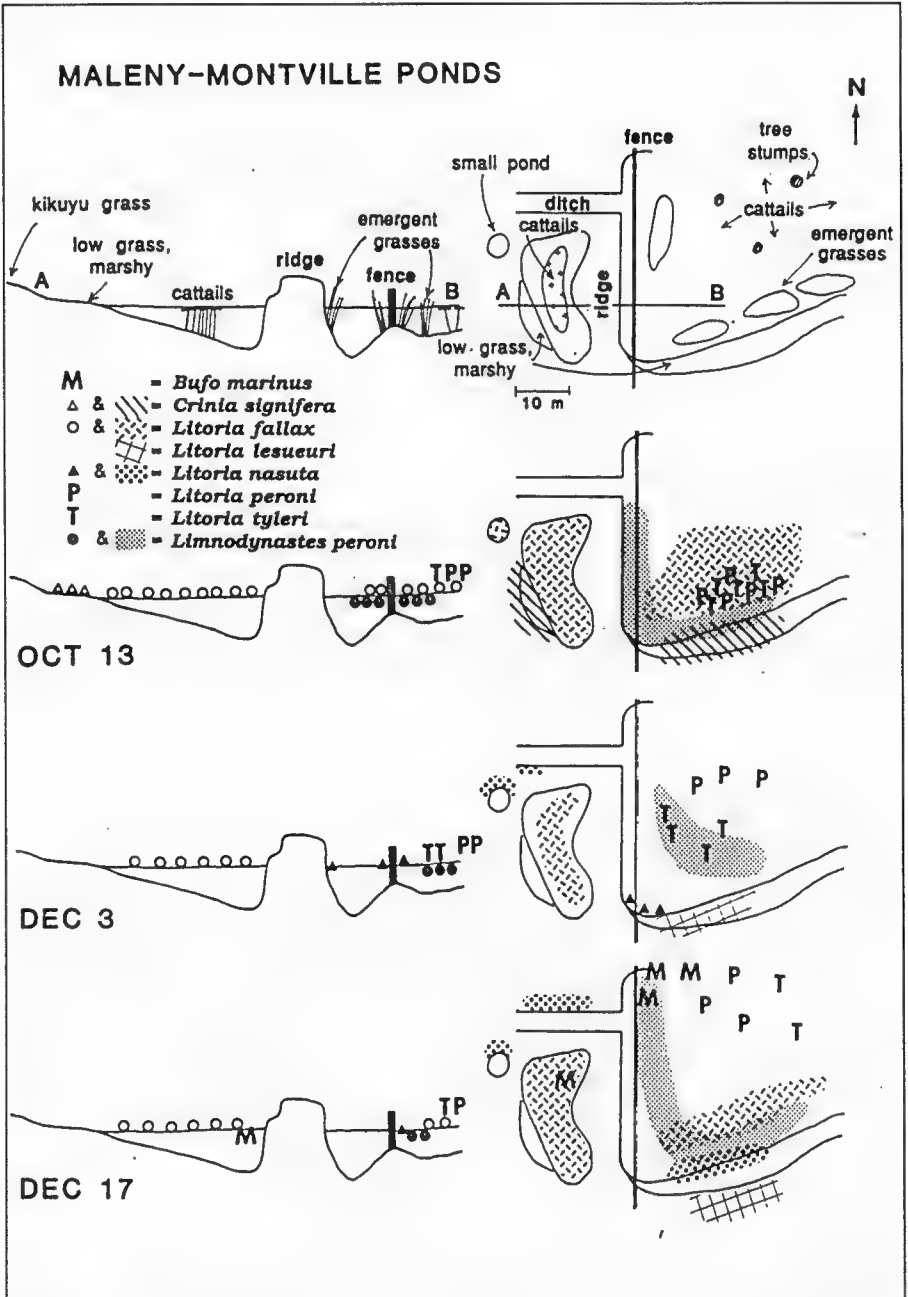
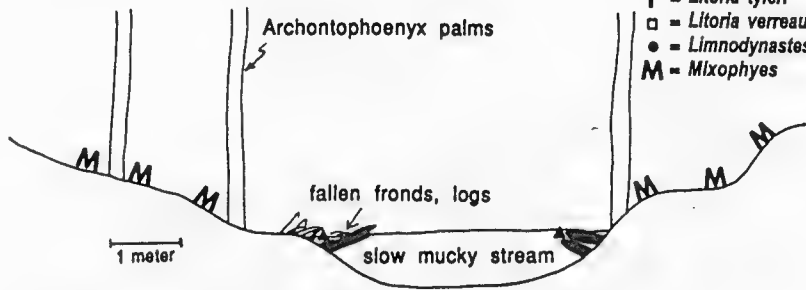


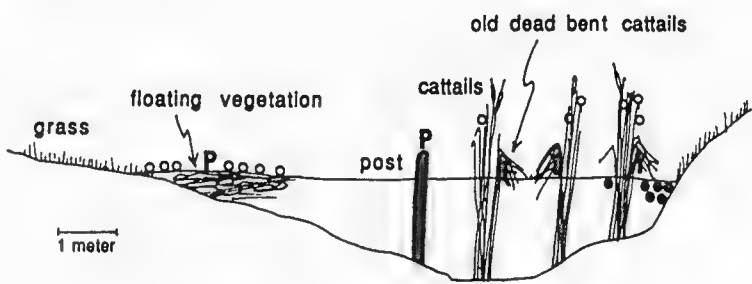
Figure 6. Microhabitats used by frogs at several locations showing utilization of microhabitats.

MARY CAIRINCROSS PARK,
MALENY - DEC 3

- ▲ - *Adelotus*
- - *Litoria fallax*
- △ - *Litoria latopalmata*
- P - *Litoria peroni*
- T - *Litoria tyleri*
- - *Litoria verreauxi*
- - *Limnodynastes peroni*
- M - *Mixophyes*



N. CONNODALE - OCT 5



5 KM S. YABBA CR. - DEC 15

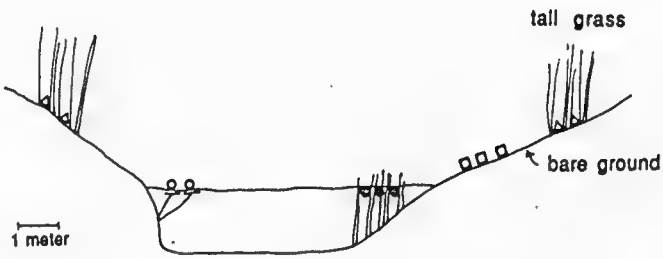
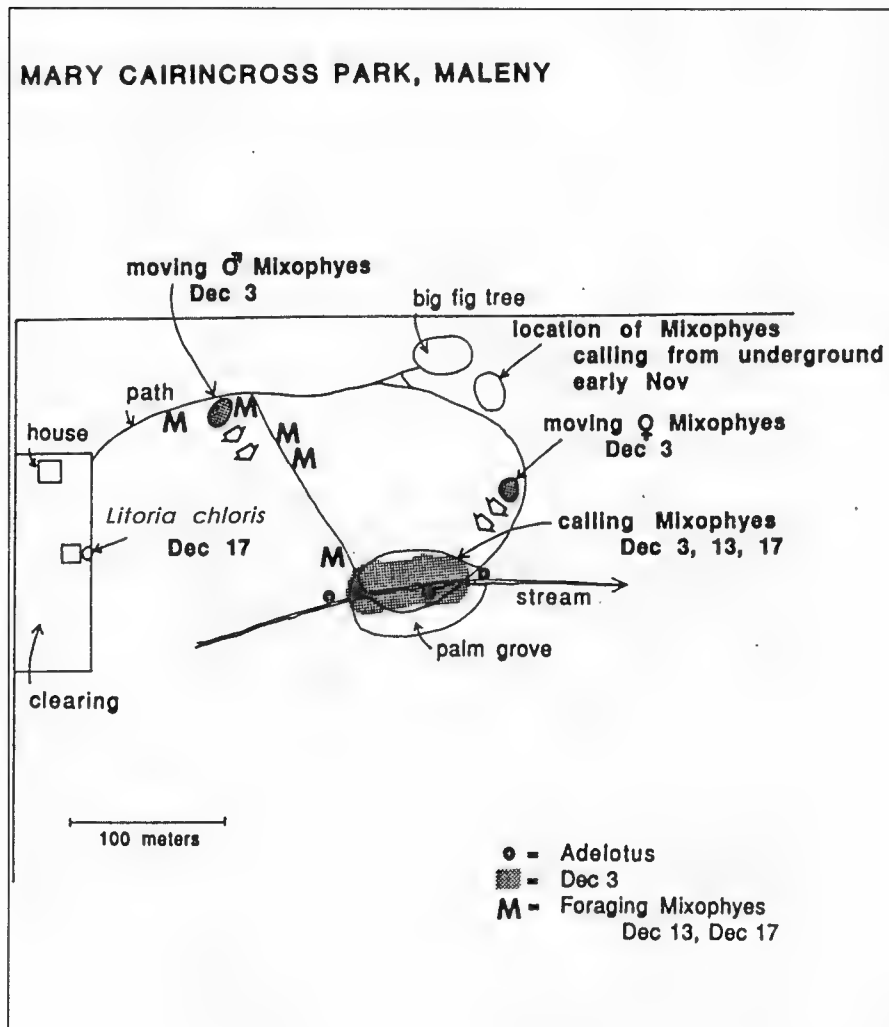


Figure 7. Microhabitats utilized by frogs in Mary Cairncross Park at different dates. Note that only three species of frogs occur at this montane rainforest site and note seasonal movement of *Mixophyes* from dry season underground retreat sites to calling sites along the small stream in December.



FIELD OBSERVATIONS OF GIPPSLAND WATER DRAGONS *PHYSIGNATHUS LESUEURII* HOWITTI SLEEPING IN WATER.

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INTRODUCTION

Water dragons (*Physignathus lesueurii howitti* and *P.l.lesueurii*) are common large diurnal lizards usually found in close association with permanent fresh-water bodies along the eastern seaboard and coastal hinterland of eastern Australia (Jenkins & Bartell 1980, Greer 1989, Swan 1990, Cogger 1992).

This note is concerned with sleep-site selection in Water dragons. There is limited anecdotal information on this aspect of Water dragon behaviour: AHS (1976) observed that the species was "seen on logs at night, usually above water"; Thompson (1993) stated that individuals were "caught by hand or noose as they slept in trees, in the water or on the river bank"; Retallick & Hero (1994) observed that *P.l.lesueurii* were "frequently seen at night resting on small branches which are overhanging or adjacent to streams"; Anthony & Telford (1996) commented that individuals in far north QLD "may be found asleep on branches at night, even on relatively cool nights in high altitude rainforest".

In this note, observations of the Gippsland Water dragon, *P.l.howitti*, sleeping in pools of water are described and the possible significance of this behaviour is discussed.

OBSERVATIONS

All observations occurred in February 1997 at various locations in southern coastal NSW and are presented in Table 1. The regions where observations occurred had not received substantial rain for some months and most creeks were dry or consisted of series of disconnected, stagnant pools.

All observations were of adult lizards asleep, and with one exception, submerged all but for the tip of the snout and nostrils. Only one *P.l.howitti* observed during night searches was

not asleep in water: it was a subadult found asleep down a dry horizontal sandstone crevice some 5m from the edge of a pool where the last observation in Table 1 also occurred.

DISCUSSION

There are several possible explanations why *P.l.howitti* choose to sleep in water. One explanation is that it affords them some protection from predators. This explanation is supported by the many observations of lizards using water as a means of escape during the day when active and also when disturbed at night (Worrell 1958, Bustard 1970, Dale 1973, AHS 1976, Retallick & Hero 1994). Retallick & Hero (1994) record a single example of predation of an immature *P.l.lesueurii* utilising an arboreal sleep-site by a Brown Tree snake *Boiga irregularis*. In far North Queensland *P.l.lesueurii* commonly use branches and vegetation overhanging creeks as retreats despite the presence in most areas of at least three predatory, nocturnal and arboreal snake species (pers. obs.). The only arboreal snake known from the general region where observations occurred is the Diamond python, *Morelia spilota spilota* (Swan 1990). However this species shows a clear preference for mammalian prey and Water dragons have not been recorded in their diet (Shine 1994 p.7-8, 27-8). Another explanation for the behaviour is that lying in water confers some thermoregulatory benefit. It is not obvious what this benefit might be given that water has a much higher thermal conductivity than air and the thermal time constants (and the generalisations about heating and cooling) determined for the species in Grigg *et al.* (1979). Ambient air and water temperatures were generally about the same when observations occurred although this was probably not the case when

the lizards' initially selected their sleep sites. It is also possible that the prevailing drought conditions in the region had some influence in the choice of sleep sites. For example, the limited water available at a number of sites may have rendered overhanging vegetation unsuitable as nighttime retreats because there was little or no water into which they could

drop if disturbed. This however did not appear to be the case for all of the sites examined. It would therefore be useful to have information on whether there is any shift in the choice of sleep sites when climatic conditions are different and additional observations from other parts of the species range

Table 1 Observations of Gippsland Water Dragons (*Physignathus lesueurii howitti*) sleeping in water. Times quoted are in Eastern Standard Time (day-light savings) and both air (A) and water (W) temperatures are in degrees celcius (°C). Maximum water depths and pool sizes are estimates.

DATE	LOCATION	CHARACTERISTICS	NOTES
19/2/97 2046hrs	Cowdroys road, Mimosa Rocks NP (36°40'E, 150°00'S)	Temp.: 20.9(A),21.6(W) Water depth: 0.3m, 0.6m (max) Stagnant 8x3m pool	Adult male asleep in shallow water at the base of a steep side of the pool. It retreated into deeper water on being disturbed.
2150hrs	AS ABOVE	Temp.: 20.1(A),20.9(W) Water depth: 1m, 1m (max) Stagnant 12x15m pool;	Adult male lying asleep in the centre of the pool. The anterior body of the lizard was partly supported by a large log that extended out from the bank.
22/2/97 2130hrs	Knights Creek cross- ing, Mumbulla SF (36°33'E, 149°57'S)	Temp.: 22.2 (A),22.1(W) Water depth: 0.3m, 0.5m (max). Still 20x8m pool in bend of creek.	Adult male lying asleep with its head and anterior body supported by a protruding rock. It retreated into deeper water when disturbed.
2132hrs	AS ABOVE	Temp.: 22.2(A),22.2(W) Water depth: 0.02m, 0.5m (max). Still shallows of 20x8m pool in bend of creek.	Adult female lay flat against the sandy substrate, asleep in very shallow water. Dorsal surface and most of lateral body surface exposed to the air.
28/2/97 2034hrs	Merrica River cross- ing, Nadgee Nature Reserve (37°19'E, 149°56'S)	Temp.: 20.7(A),20.7(W) Water depth: 0.12m, 2m (max). Still 16x12m pool	Adult female asleep in shallow water on a rock shelf on the edge of pool. It swam across to the opposite side of the pool when disturbed.

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A SHORT NOTE REGARDING A NORTHERLY RANGE EXTENSION OF HASWELL'S FROGLET *PARACRINIA HASWELLI* (FLETCHER, 1894).

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Haswell's Froglet *Paracrinia haswelli* is a small, south-eastern Australian myobatrachid species with a generally accepted distribution extending from the Mornington Peninsula, Victoria, in the south to just north of Sydney in central New South Wales (Hero *et al.*, 1991; Cogger, 1992; Barker *et al.*, 1995; Healey, 1997). Restricted to coastal areas, this species commonly inhabits a number of diverse habitats, typically among vegetation in association with water bodies or swamps (Cogger, 1992). According to contemporary field guides the distribution of this predominantly south coast species diminishes in range in the central coast region of New South Wales (Cogger, 1992; Tyler, 1992; Barker *et al.*, 1995), while the species has been detected as far north as the Myall Lakes System (Markwell and Knight, 1986 as cited in Hamer, 1996). This short note details the collection of several specimens of Haswell's Froglet within Limeburners Creek Nature Reserve on the mid-north coast of New South Wales, some 160 km distant of the most northerly recorded locality of this species. Suggestions are provided to alleviate inaccurate distributional data for amphibians and further biological surveys of Limeburners Creek Nature Reserve are recommended.

Situated approximately 375km north of Sydney and 430km south of Brisbane, Limeburners Creek Nature Reserve (152° 57'E, 31° 17'S) protects 9125 hectares of coastal lowland and dunal systems, incorporating a number of diverse habitats ranging from littoral rainforest, wet and dry heathland to dry sclerophyll forest and woodland (Morante, 1996, NPWS, 1996). Around 70% of the reserve is wetland, of varying inundation, accentuated by Saltwater Lagoon in the approximate geographical centre of the reserve.

Between the 7-18th of February and 16-25th of June 1996, dry pitfalling was conducted at various sites throughout the reserve with the aim of documenting the amphibian fauna of the reserve (Morante and Richard, in prep.; Morante, 1996). Eight sites were sampled within the reserve throughout this period representing seven diverse habitat types. Specimens were identified *in situ* according to Cogger (1992) and Robinson (1993). As a result of these surveys, four specimens of Haswell's Froglet (*Paracrinia haswelli*) were detected within the wet and dry heathland vegetation association. One of these captures was detected by pitfall in dry heathland while the remainder were detected during active searches along an inundated access trail running east-west through the reserve. This access trail was characterised by wet heathland and, at the extreme centre of the reserve, sedgeland. Voucher specimens were not obtained of any of these captures as their identification was regarded as correct at the time of collection.

The collection of Haswell's Froglet within this reserve, approximately 160 km further north of its previously most northerly recorded locality, indicates that this study provides further indications of deficiencies or inconsistencies in our current distributional knowledge for at least some frog species. Similar range extensions have been recorded for a number of species, most recently the Broad-palmed Frog *Litoria latopalmata* (Rauhala and Osborne, 1994; Lemckert *et al.*, 1995) and the Wallum Froglet *Crinia tinnula* (Ehmann, 1997). Current field guides often contain misleading distribution maps that may lead future field investigators, particularly those with limited experience, to disregard records

of species obtained outside the current distributional range of that particular species. This has implications regarding the current national and global amphibian decline phenomenon and the establishment of baseline data with which to compare prior or future declines.

The establishment of a national, computerised database, containing complete and updated species distribution records, modeled on that of the Royal Australasian Ornithologists Union (Birds Australia) Atlas of Australian Birds (Blakers *et al.*, 1984), would go part way in alleviating this lack of baseline ecological data. This database could be linked through state environmental agencies (similar to existing fauna records databases such as the NSW National Parks and Wildlife Services' Atlas of NSW Wildlife) and natural history groups and societies or be accessed directly via the burgeoning internet or worldwide web (WWW). Up to date records could be lodged in the database through the transmission of a simple form, after completing set fields such as the latitude and longitude of the collection location, habitat type, nearest major town and other relevant observations.

As further field surveys are conducted, particularly in more remote regions, similar extensions of range are highly likely to occur, making the establishment of such a centralised database containing accurate and up to date distributional records all the more essential. It is recommended that further surveys of Limeburners Creek Nature Reserve be conducted to gather more data on the resident amphibian populations.

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The members of the committee overseeing the Fund are Dr Harold G. Cogger, Dr Allen E. Greer, Mr Neil Rankin and Mr Philip Rankin. Contributions to the Fund are continually being sought and are tax deductible.

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HERPETOLOGICAL NOTES

AN OBSERVATION OF A POSSIBLE WILD MATING ATTEMPT FOR THE WATER MONITOR, *VARANUS MERTENSII*

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The water monitor, *Varanus mertensi*, is distributed throughout tropical northern Australia, where it inhabits river banks and swamps (Cogger, 1992). Little is known regarding its reproductive biology. Shine, (1986) reports females being gravid in April and June, and in reproductive condition in December. I observed what appeared to be an attempted mating in July, at Mt. Ford, Litchfield National Park (130°48' E; 13°02'S), Northern Territory. The behaviour observed was as follows:

Two *V. mertensi* were sighted, one was larger, presumably the male, and was swimming in a stream. The smaller, presumably the female, was basking on a rock. The male exited the water, approached the female from behind and tongue flicked her tail. He then moved beside her, to her right, all the while his tongue was flicking rapidly. He rubbed his head against hers. He then lifted his left leg and straddled her. They both laid motionless with the male on top for up to five minutes after which time she fled into the water. It was difficult to see if copulation occurred from my position. He did not chase her but basked in the position she recently occupied.

This could have been a mating attempt since it is similar to mating behaviour described for

V. rosenbergi (King & Green, 1993) and *V. panoptes* (R. Pengilly, pers. comm.). On the other hand, it could have been one individual displacing another at a preferred basking site, since it was not confirmed these were of opposite sex. Due to its association with permanent water, *V. mertensi* is not constrained to periods of inactivity as are other tropical varanids (Christian, *et al.* 1996). This may be reflected by an extended reproductive period beyond that postulated by Shine, (1986) of April to June.

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OPHIOPHAGY IN A KING BROWN SNAKE (*PSEUDECHIS AUSTRALIS*) FROM CENTRAL AUSTRALIA.

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At 7.30pm on the 7th of September 1997 in Simpsons Gap National Park, 25km west of Alice Springs, we unearthed a large (approx. 1.8m) *Pseudechis australis* (king brown snake) which had consumed a large (0.9m) female *Antaresia stimsoni* (Stimmons' python). The python was a study animal which had had a small transmitter implanted in its abdominal cavity in April 1997. Since its release in April it had been monitored intermittently and its location noted. The animal had not moved from a sealed chamber beneath a park path between late autumn and early spring (5th of September 1997). On the evening of the 6th of September it moved about 3m, still under the path, from the sealed chamber. On the afternoon of the 7th of September it was found to have moved about 150m from the overwintering refugia. As the animal was active and a blood sample was needed as part of an energetics study, an attempt was made to recover it. All that was recovered was the very large king brown snake which was retained to recover the transmitter and python. The next morning the python was regurgitated, still in reasonably good condition but minus the skin on the head and neck area. The king brown snake had only recently eaten the python, possibly as it emerged from the overwintering refugia. The body of the python was retained to recover the transmitter and take tissue samples. The *P. australis* was measured, photographed, then released.

Of interest on the king brown snake were a number of large scars which had healed but had obviously been a major trauma to the snake at some stage. Two other large king brown snakes in the MacDonnell Ranges have been found with similar scars. Possibly these scars may have been caused by Peren-

ties (*Varanus giganteus*), wild dogs or raptors. If so the scar frequency may indicate a high rate of attack and result in considerable king brown mortality.

It appears that few *A. stimsoni* are active in the cool early weeks of spring and prefer to remain in a subterranean refugia until the weather warms up. However, king brown snakes become increasingly active during this cool spring time and being a snake which will eat most animals it can get into its mouth, a slow cold python is a good meal. King brown snakes have been identified as feeding on reptiles (Shine 1991) and even carrion (Bedford 1991). Ophiophagy in *P. australis* is not new, and possibly snakes are a substantial part of their diet. What is interesting is that the python had been active for less than one day. The python was a reproductive female (large follicles found during autopsy) and may have moved from the refugia for food or to seek a mate, however, she met a less than deserving fate.

ACKNOWLEDGMENT.

Permits supplied by Parks and Wildlife Commission of the Northern Territory. Thank you to the reviewer.

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SPRING BREEDING AGGREGATION OF THE BLINDSNAKE *RAMPHOTYPHLOPS NIGRESCENS* (TYPHLOPIDAE)

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Mixed-sex aggregations of adult Australian blindsnakes were reported by Shine and Webb (1990) and assumed to be related to breeding activity, but no instances involving actual copulation have been described. Surprisingly, in view of their abundance and almost worldwide distribution, Ehmann (1992: 342) states that mating has not been observed in (any) typhlopids. This has apparently remained the case until recently (see Greer 1997: 12). The observation reported below fills this gap in knowledge for one of these species.

The authors conducted a survey of a proposed development site at Dural, NSW (33°41'S, 151°02'E), on 11-12 October 1997. On both days there was no cloud cover, very light N to W winds, and temperatures reached approximately 35°C (11th October) and 27°C (12th). The site is on a north-facing slope, partially cleared (for a dam and pasture in the upper part of the site, and below power lines crossing the lower end) but retaining diverse and mainly native dry sclerophyll vegetation. It is bounded to the north by a creek, and adjacent to wet sclerophyll forest, open pasture, and a house. *Litoria verreauxii* (Verreaux's Tree Frog; among rocks adjacent to the dam and a culvert), *Lampropholis guichenoti* and *L. delicata* (Paleflecked and Dark-flecked Garden Skinks), and *Ctenotus taeniolaemus* (Coppertail Skinks) were common, and one or two individuals of *Oedura lesueurii* (Lesueur's Velvet Gecko), *Phyllurus platurus* (Southern Leaf-tailed Gecko), *Pseudemoia platynota* (Red-throated Skink), *Eulamprus quoyii* (Golden Water-Skink), and *Ctenotus robustus* (Robust Skink) were also observed. Most reptiles were associated with sandstone outcrops, either active in grass or litter, in

crevices (*Phyllurus*) or under exfoliated slabs. Although the outcrops had apparently not been exploited by 'bush rock' collectors, only two or three rocks on the site looked like suitable day-retreats for *Oedura lesueurii* (based on the first author's experience, cf. Schlesinger and Shine 1994).

Six individuals of the blindsnake *Ramphotyphlops nigrescens* were found at about mid-day on the first day, in tunnels under partly embedded rocks (between 3 and 8cm thick) flanking a domed outcrop. Blindsnakes can usually be reliably sexed based on tail length, which is relatively much shorter in females (e.g. Ehmann 1992: 342). A single female was under one rock (total length approximately 28cm, so possibly still immature, cf. Shine and Webb 1990). Several metres away, two adjacent rocks covered one juvenile (total length estimated at 11 cm) and one larger female (approx. 33 cm) together with three adult males (each approx. 28 cm). Copulation was inferred to be taking place, as the vents of the female and one of the males were tightly opposed, and they remained joined together while handled for a minute or so. No appreciable length of the hemipenis was seen exposed, although some tension was inevitably exerted on it during handling. The pair separated only after being replaced on the ground, when they crawled off in different directions.

Aggregations of blindsnakes, mostly juveniles and subadults, can occur at any time of the year (e.g. Hoser 1980). The sandstone outcrop (with nearby nests of at least six species of ants, ranging in size up to *Myrmecia* sp.) could possibly support a number of *R. nigrescens* individuals year-round. Alternatively, it may have been used as an overwintering site; the snakes were observed on the

first very warm day of the spring, so they may not yet have moved far. In any of these cases, the proximity of the single female and the juvenile to the other snakes could be purely incidental. However, the other two males being in direct contact with the mating pair suggests that they were also involved in the breeding activity, perhaps in a competitive selection process. Shine and Webb (1990) reported aggregations of one adult female and one to three males of *R. nigrescens* in the months from September to January, with oviposition occurring from December to February. Our observation confirms the expectation that copulation does take place during these spring aggregations, and suggests a role for rising temperature in triggering mating activity.

ACKNOWLEDGMENTS

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PARTURITION IN THE TUSSOCK SKINK, *PSEUDEMOIA PAGENSTECHERI*

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The Tussock Skink, *Pseudemoia pagenstecheri*, is a small (40–70 mm adult snout-vent length) viviparous skink which occurs in tussock grasslands in temperate southeastern Australia and Tasmania (Hutchinson and Donnellan 1992). Mating in *P. pagenstecheri* occurs in autumn, females ovulate in spring, and the young are born in summer (Pengilly 1972, Hutchinson and Donnellan 1992).

Gravid females were collected during late

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- January and early February of 1991 to 1993, as part of a study of growth and life history in a subalpine population of *P. pagenstecheri* (Hudson 1997). The collection locality was Shaw's Creek, Bennison Plains, in the Alpine National Park, Victoria (37°28'S, 146°44'E; elevation 1280 m), approximately 250 km east of Melbourne. Females were temporarily housed in individual glass aquaria (45 x 20 x 25 cm), with paper towelling on the bottom. Heat lamps were positioned over one end of each aquarium to provide a temperature

gradient for thermoregulation, water was available *ad libitum*, and food was supplied in the form of mealworms and crickets. A total of 22 females produced litters in the laboratory, and parturition occurred on 1-16 February in 1991 ($n = 14$), 4-6 February in 1992 ($n = 3$), and 15-16 February in 1993 ($n = 5$). Neonates were first observed in the field at Shaw's Creek on 25 January 1990, 28 January 1991, and 1 February 1992.

Parturition was observed in nine females. Immediately before parturition, females stood with their hind legs spread wide apart and their pelvic area and tail arched. Neonates were born quickly, and usually emerged completely within 5 seconds. Most emerged head first and unattached to any extra-embryonic material, although some emerged curled up in a transparent sac, which promptly broke. Neonates generally emerged onto their back, where they lay briefly. After 1-2 minutes the neonate would right itself and unsteadily move away, appearing somewhat uncoordinated at first. Births took place at intervals of 10-20 minutes, and between births the female moved freely around the aquarium or basked under the heat lamp, turning periodically to lick and bite at the vent area.

A substantial amount of extra-embryonic material followed each birth, perhaps as much as the neonate itself. The female immediately ate this material, pulling it from the vent and licking the vent and the substrate of the birth site. Females frequently bit the vent area and even their own hind feet, occasionally appearing to chew on their feet. No neonates were ever observed to eat any of the extra-embryonic material, as has been reported in some other larger Australian skinks (Greer 1989, Bull *et al.* 1993, Duffield and Bull 1996).

No attempt by a female to assist a neonate in any way was observed, and on a number of occasions the female was observed to lunge

at and attempt to seize a just-born neonate lying on its back, which would immediately turn over and run away. Neonates appeared to avoid and hide from the female once they were active. Females ate one or more of their young in a small number of cases where they were not removed quickly enough.

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BOOK REVIEW

Carl Gans and Abbot S. Gaunt., editors, *Biology of the Reptilia. Volume 19, Morphology G. Visceral Organs*. Society for the Study of Amphibians and Reptiles

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This is the latest volume in the well-known series of the *Biology of the Reptilia* that first appeared in 1969. The intent of each volume in the series is to provide chapters written by specialists covering a particular area of reptile biology. The series is edited by the eminent herpetologist, anatomist, functional morphologist and friend of Australian herpetology, Carl Gans and various colleagues depending on the subject matter. The volumes are unashamedly intended for the specialist. Little quarter is given to the non-specialist, and most general herpetologists, once outside their own areas of interest, find the going a bit tough. The two volumes preceding the current volume, one on sensorimotor integration and the other on hormones, brain and behaviour, were so ethereal in their erudition that their readership must have been quite select. The latest volume is more generally accessible.

The current volume is the seventh in the series to deal with the general topic of morphology. It covers several visceral organs not dealt with in earlier volumes, specifically, the lungs (two chapters), pulmonary function, the heart, cardiovascular function, the liver and the spleen (one chapter each). The series is now so venerable that some of the topics, in the present instance, pulmonary function, are being revisited.

One of the most useful aspects of the series is that most chapters attempt to provide authoritative reviews of the literature on the topics covered. However, these vary in thoroughness, depending in large part on the interests of the authors. For example in the current volume, V. Wallach's review of snake lungs provides one of the most thorough reviews of the literature and unpublished work given any topic in the entire series. In contrast, S. Perry's review of lizard lungs is a pale shadow of Wallach's effort. But Wallach's interest is mainly in snake diversity and detailed phylogenetics, whereas Perry's interest is in the general morphology and function of reptile and bird lungs. Wallach's review is a campaign of epic proportions whereas Perry's overview of the literature is a symbolic waving of the flag.

Other noteworthy chapters in the volume include T. Wang, A. Smits, and W. Burggren on pulmonary function, and J. Hicks on cardiac shunting (the capacity of the lung and body cir-

culations under certain circumstances to feed back into themselves instead of passing from one to the other). Both chapters are clearly examples of the specialist writing specifically on his topic of interest. In contrast, the chapters on the morphology or the heart, the liver and the spleen cover the general ground but without achieving the intimate detail that is evident in the chapter on snake lungs, pulmonary function, and cardiac shunting. I suspect this is because these chapters were written by workers for whom reptiles comprised just a small part of a broader general interest.

Another feature of the morphological volumes in the series is that the individual contributions often try to rationalise the diverse nomenclature surrounding a subject and to clarify a topic that has perhaps gained a reputation for being difficult or confused. In this volume Perry's introductory contribution presents a very clear and concise proposal for the stabilisation of the terms used to describe lung morphology, while Wang et al. and Hicks make the potentially difficult topics of pulmonary function and cardiac shunting respectively, accessible to the committed reader.

Like the other morphological volumes in the series, this volume provides many examples of how far descriptive morphology has run ahead of its evolutionary and functional contexts, in other words, its relevance. Several chapters, most notably those on the heart, liver and spleen, contain enticing details of distinctive anatomical features of which one may ask either reverentially, "How widespread is this feature among its close relatives and what function could it possibly serve?", or more bluntly, "So what?" And in general, the best persons to have answered those questions would have been the original authors, who at the time of the original research obviously had the knowledge, the experience and the techniques to pursue the answer. But unfortunately, many morphologists appear to have been little interested in pursuing their discoveries in such detail. Why this is so is one of life's little mysteries. But as a consequence, many of their discoveries lie entombed, lucky to be brought briefly to light in volumes such as the present one before once again falling back into the crypt.

NOTES TO CONTRIBUTORS

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